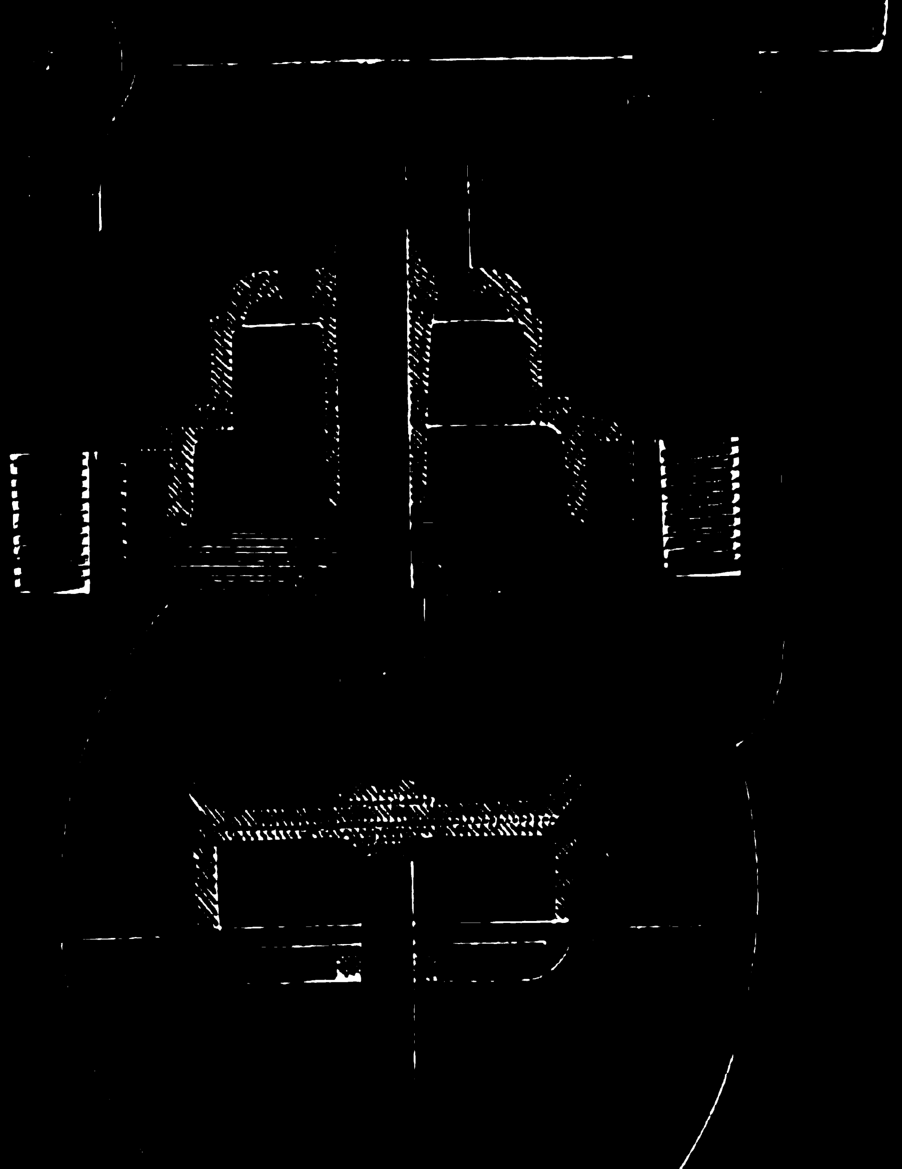
Fig 1



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THE

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OF THE

FRANKLIN INSTITUTE

DEVOTED TO

SCIENCE AND THE MECHANIC ARTS.

EDITED BY

WILLIAM H. WAHL, PH. D.

ASSISTED BY THE COMMITTEE ON PUBLICATIONS.

Vol. XCV.—No. 564.

THIRD SERIES.

Vol. LXV.—JANUARY, 1873.—No. 1.

PHILADELPHIA:

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1873.

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JOURNAL

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1873.

Errata to Vol. LXV.

On page 211, 16th line from top, *read* Tables of Venus.

" 313, in formula near bottom of page, minus sign is omitted; read

$$v=\left(\sqrt{0\cdot0081\,b+\left(\frac{225\,a\sqrt{s}}{p+W}\right)^{\frac{1}{2}}}-0\cdot09\sqrt{b}\right)^{2}$$

INDEX.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA.

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LXV.] JANUARY, 1873. No. 1

EDITORIAL.

ITEMS AND NOVELTIES.

The Wharton Safety Railroad Switch—BY WILLIAM H. WAHL.*—Any invention or discovery which in any degree serves the purpose of throwing some additional safeguards about railroad travel, becomes so much a matter of personal interest that no preliminary remark is necessary to introduce it to the notice of the reader. One of the most useful and popular of American inventions in this direction is the Wharton Safety Railroad Switch. The inventor has succeeded in producing a mechanical device which has proved itself in practice to realize so nearly the conditions of perfect safety, that there is now no valid reason or justification to be offered for that most common of excuses in railway disasters—"a misplaced switch." That the merits of the invention are recognized, is evinced from the fact that many of our best railroad companies have adopted it upon their entire lines to the exclusion of all others. The chief objects accomplished by the device consist in leaving the main track of the road entirely undisturbed and continuous, and in securing—as nearly as such a thing is possible in practice—perfect safety to trains, should the switch, either by accident or design, be left wrong; and this without injury to the switch.

* From the Am. Exchange and Review, October, 1872.

The accompanying illustrations show the switch in its two positions. Fig. 1 shows the switch open and entirely removed from the main track. Fig. 2 shows it closed and in position to transfer cars from the main track to the siding. The essential parts of the switch are the two switch-rails, a fixed and a movable guard. One of the switch rails, it will be observed, is of a peculiar grooved form with a pointed end, which lies just within the head of the main track rail. The function of this arrangement will shortly appear. The switch-rails and the movable guard rail, which are in connection with each other, may be removed entirely away from the main rails, when not required (Fig. 1), when they neither touch, nor in any manner act upon the car wheels, and for all practical purposes no switch is present. When moved in the position of Fig. 2, the switch is ready to act in transferring cars to the siding. The operation would be about as follows: The train moving in the direction of the arrow, would pass the switch upon the main tracks, when the switch would be closed (Fig. 2) by the attendant, and the train backed down into it. The fixed guard will first come into play in slightly drawing the wheel on the opposite side away from the main rail, so that its flange may certainly pass into the grooved switch-rail. The opposite wheel being now pressed against the main rail on its side, a portion of its outer tread is brought to bear upon the switch-rail directly aside the main track. This switch rail, however, slightly inclines upwards, so that the wheel in its passage is quietly raised, and in the space of four and a half feet is entirely upon the outer switch-rail; its flange having passed up an incline sufficient in height to raise it entirely above the main track rail. The opposite grooved switch-rail has, during the same time, performed for the opposite wheel the same function; so that both wheels being now upon the siding, the transfer is practically accomplished.

The cranks attached to the shaft of the operating mechanism are fixed at such an angle with each other, that while the pin holding the switch is upon the dead-centre, or slightly below it, that at the other end is at such an angle that it can be readily operated by the connecting rod from the movable guard-rail. Any lateral pressure, therefore, applied to the switch-rails will only have the effect of pressing the lever which operates them, more firmly down upon the cross tie on which it rests, and thus hold the rails more strongly in position.

After the operation of transferring a train to the siding is effected, it is intended that the switch should be returned again to the o[illegible]

position of Fig. 1. But, supposing that either through accident or design it should remain unchanged, it is impossible that an accident should occur, from the provision which the invention affords for completely meeting such a contingency, should a fresh train arrive (of course in the direction of the arrow), with the switch misplaced; the engine wheel bearing against the inner edge of the movable guard-rail would readily operate the favorably placed crank connecting the same with the switch-rails, and these would be instantly moved clear from the track in the position of Fig. 1, leaving the latter free for the passage of the train. The accidental starting of a train just switched off could also be followed by no further evil than its running again upon the main track. Should the switch be left open by accident or design after a train has been run upon the siding—instead of being closed, as it should be—there are two siding castings called guards (not shown in the engravings), which bring the train on the siding safely back again on the main track. In no case is it possible for an accident to occur from the action of the switch, unless we except the possibility of such stupidity as the running one train off upon the siding into another; and even this danger may be obviated thus: Where a single track is to be provided for, the switch will not remain set for the siding; for, by the introduction of a simple device, the presence of an attendant is required to keep the apparatus in position to act as a switch. As soon as the attendant releases his hold, the switch-rails return to their open position, leaving the main track clear—thus securing the safety of trains moving in both directions.

It will readily be perceived by those acquainted with the subject, that other advantages, involving the question of economy, are to be considered, in addition to that of safety, in enumerating the superior merits of this invention. From this point of view, the saving in wear and tear of the rolling stock from the constant jolting which accompanies the use of the ordinary switch, as well as that of the switch itself, form prominent points for consideration.

As one of the many indications of the favor with which it has been received in official railroad circles, the following letter, from Col. Thos. A Scott, will serve the purpose.

PENNSYLVANIA RAILROAD COMPANY,
OFFICE OF THE VICE PRESIDENT.

Philadelphia, January 25th, 1871.

A. BARKER, Esq., President Wharton R. R. Switch Co.

My Dear Sir.—After careful experiment upon our road at several points where it could be most thoroughly tested, during which you have perfected the

Wharton Railroad Switch, so that we think it adapted to all our wants, we have concluded to adopt it on our own road and the roads leased by us; and will give it place as rapidly as we can do so consistently with the proper maintenance and operation of the line.

I believe that it will prove of great practical value to all the Railways of the country. Very respectfully yours,

THOMAS A. SCOTT, *Vice-President.*

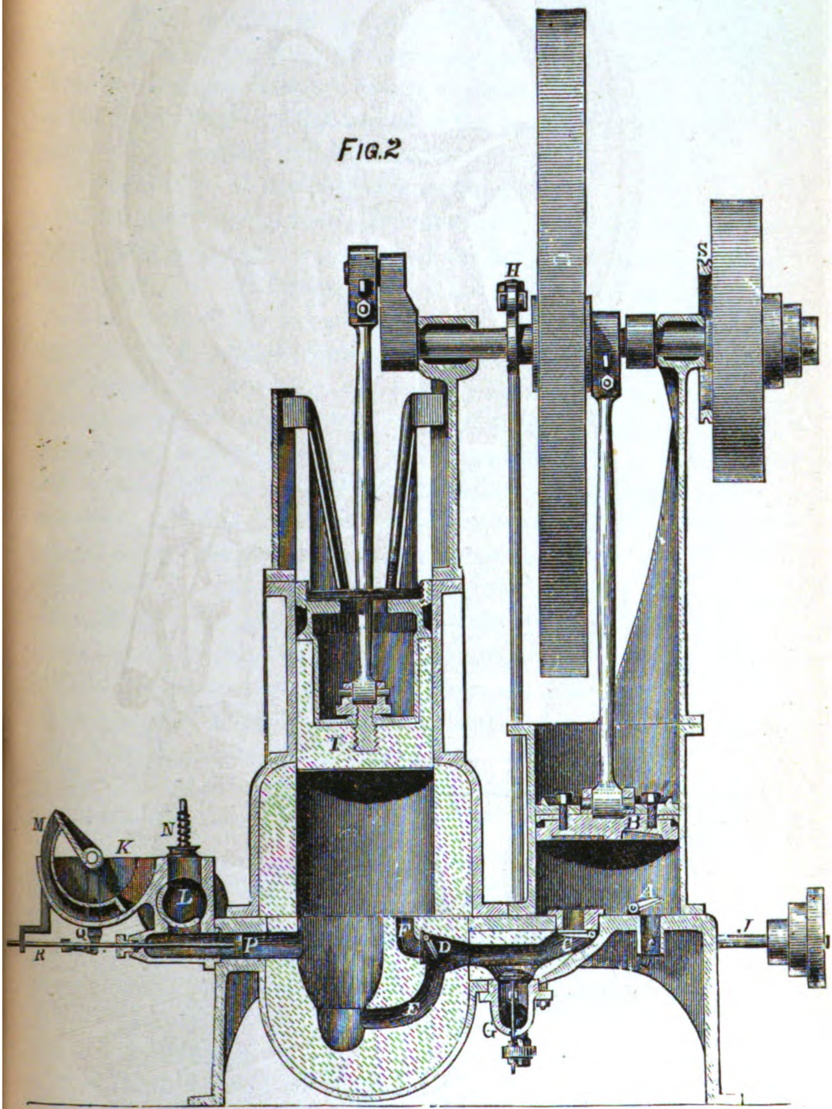
Besides this valuable endorsement, it has also received from numerous other prominent railroad managers equal commendation. All the wearing parts being constructed of Bessemer steel, the switch is extremely durable. Targets and signals of any kind, for indicating the position of the switch, are rendered entirely unnecessary.

The Howard Super-heated Air Engine.—We give, with the accompanying illustrations, a brief description of this somewhat novel form of motor, which attracted considerable notice at the recent industrial exhibition of a neighboring city.

Referring to Fig. 2, a vertical section—Fig. 1 being a perspective view—A represents the induction valve of the air-pump, and B, the air-pump plunger. C and D are stop-valves in the air-passage from the pump to the fire-box. The air-passage has two branches. The branch, E, leads to the fire-box, and the branch, F, is the exhaust passage from the cylinder of the engine leading back to the general passage, of which G is the exhaust port. The valve which opens or closes the port, G, is actuated by a cam, H, and a suitable connecting rod. I is the piston of a hot-air cylinder. This piston is lined with soapstone, and so made that a little annular space is left between it and the upper half of the cylinder, except at the top, where it meets the cylinder to form an air-tight packing. The lower part of the cylinder is thickly lined with soap-stone, as is also the fire-pot immediately below it. The exterior of the hot-air cylinder is protected from the heat by a cold-water jacket. The heat, however, is not so intense but that this jacket may be dispensed with.

J is a shaft which, driven from the cone pully on the fly-wheel shaft, operates the coal-feeding apparatus by an automatic arrangement. The coal is placed in the hemispherical receptacle, K. A semicircular feed-bar, M, oscillates on a pivot, and at each oscillation raises on its inner end a small modicum of coal. A wire brush, N, which has a horizontal movement, brushes off the coal thus raised into the open mouth of the cock, or gate, L, the latter being so constructed that it completely closes the passage to the fire-box, both when receiving the coal and when delivering it into the cylindrical passage in front of the

FIG. 2



THE HOWARD A

plunger P. The plunger, P, is actuated by an arm, Q, linked to the rod, R. When the fire-box is full, the plunger, P, meets so much resistance as to prevent its reciprocation. It then causes the belt to slip on the cone pulleys, and thus retards the feeding.

O is a damper placed in the port of the induction-valve of the air-pump. This damper is controlled by a governor, shown in Fig. 1, and which is driven from the grooved pulley on the fly-wheel shaft. When the damper closes, it causes a partial vacuum in the cylinder of the pump, resisting the ascent of the piston, and thus reducing the power of the engine, and vice versa.

The operation of the engine is as follows:

As the pump-piston rises, air enters at A to fill the pump-cylinders. The cranks of the pump-piston and the hot-air cylinder-piston are set at right angles. It follows that on the descent of the pump-crank to the lower centre, the hot-air piston will have passed the bottom centre, and will be at mid-stroke. When the pump-piston is at mid upward stroke, the hot-air piston-crank will be at the upper centre, and the hot-air piston will be at the end of its upward stroke. When the pump-piston arrives at the end of its upward stroke, the hot-air piston will be at mid-downward stroke, and when the pump-piston is at mid-downward stroke, the hot-air piston is at the end of the downward stroke, being brought to that position by the motion of the fly-wheel. When the hot-air piston is at the end of the upward stroke, the exhaust takes place. The hot-air piston then descends to mid-stroke, when, the pump-piston beginning to descend, the cold air from the pump-cylinder exhausts, together with the hot air from the hot-air cylinder, the mingling of the cold and hot air so far reducing the temperature that the exhaust-valve is not injured.

The exhaust closes a little in advance of the full descent of the hot-air piston, and also a little before the pump-piston reaches the mid-downward stroke, giving a little compression. Then, as the pump-piston is traveling rapidly downward, while the hot-air piston is rising slowly, having just passed the center, the air is condensed somewhat by the force of the fly-wheel. As the hot-air piston rises rapidly after passing the lower center, the pump forces the air remaining in it into the fire-pot. The rapid expansion of the air in heating now forces the hot-air piston upward.

The valve, A, is of brass, faced with leather; and to prevent its noisy fluttering, it is operated or steadied by a light steel finger, manipulated by a delicate cam and rod not shown in either view. The

valve, C, opening within the passage, is simply of brass, and is accessible from the inside of the pump by removing the seat. The pump piston is packed with the best oak-tanned cap leathers, carefully turned and fitted, and is claimed to require no attention beyond being lubricated, for long periods of time. The valve, G, requires to be reground to its seat once in six months, only the work of twenty minutes. The valve, D, is simply a damper valve, made of light Russia iron, and does not require to be air-tight.

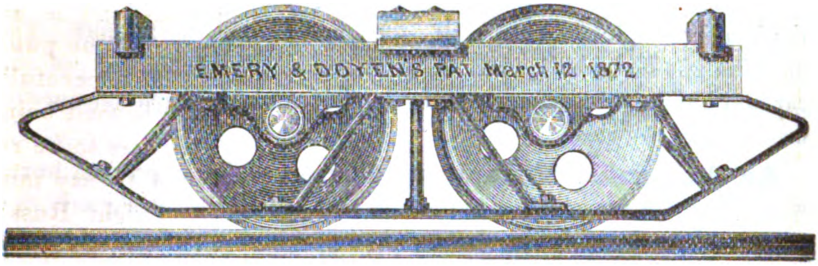
The packing found most convenient is the common soapstone packing. The cylinder being open at the top, it is very convenient to apply a small portion of tallow, or tallow and beeswax, occasionally. The packing is kept screwed down by means of a follower ring turned with a spanner.

For the engine here described as fully as space will admit, the manufacturers claim a number of advantages, among which are those of simplicity, durability and compactness. They build an engine of 6-inch cylinder, which is strongly recommended for a great variety of light work, and especially as a pumping machine for household work. This small engine was on exhibition at the late American Institute Fair in New York city, where also are located the head-quarters of the manufacturers.

The Hoosac Tunnel.—To the record which we have presented from time to time of the progress of this interesting engineering project, we can now add a piece of information which carries with it the intimation that the "beginning of the end" is at hand. On the 12th of December, after some unusually heavy blasting, a union was effected between the workings on the east end of the tunnel and the central shaft.

The great hindrance caused by water in the central shaft, and which has repeatedly caused serious stoppages in the work at this part of the tunnel, besides the expense attendant upon the erection and constant operation of pumping machinery, is now at an end; the waters having now a free drainage into the Deerfield river. From present indications, the remaining portion of the boring, viz., four thousand feet between the west end and the central shaft will be completed, and the tunnel ready for use by October, 1873, or three months within the period agreed upon by the contracting parties.

A Safety Shoe for Railway Cars, etc.—In the last issue of the "Journal," attention was called, in a brief item, to this invention, which had been for some time on exhibition in the city.



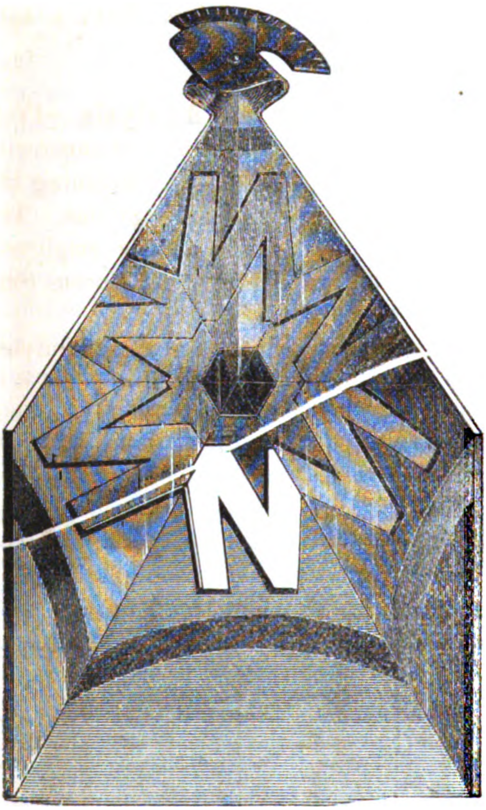
Since that time we have been favored with an excellent engraving, showing the device in side-elevation, from which the appearance of the new attachment and its function as a safety apparatus will readily be observed. There seems to be some probability that the device will soon receive a practical test upon several of our railroads, and we shall await the results of such experiments with interest.

An Enormous Snow Plow.—The Union Pacific Railroad is having built, at its shops at Omaha, a snow plow which, when finished, will be the largest and most powerful in the world. It is rapidly approaching completion, and in a few days will be ready for business. The trucks on which it is built are very heavy and strong, and were cast especially for this plow. The platform on these trucks is 22 feet long, and 10 feet 6 inches wide, and is composed of solid oak timbers, 8 by 16 inches. These timbers are held together by ten iron bolts, $1\frac{1}{4}$ inches in diameter, which run crosswise. This solid bed is fastened to the transom beams by forty bolts, twenty over each truck. The inclined slide, placed on the platform, is 22 feet long, and slopes at an angle of 30 degrees, and is held firmly to the bed by 40 bolts, of an inch in diameter, and is supported from behind by inclined posts, 6 feet long, 8 inches wide, and 16 inches thick. The entire length, from the rear of the platform to the end of the slide, is 32 feet. The slide is to be ironed, and an immense plow, of the ordinary shape, 18 feet long, 11 feet wide, and 5 feet high, and covered with iron $\frac{3}{16}$ of an inch thick, is to be securely placed upon it. On the point of this plow there is to be an iron plate, steel pointed, 11 feet long and four feet wide. This plate runs across the track, and only 1 inch above it.

The rear of the platform will be boxed in, making a room 12 feet high, 11 feet wide, and 10 feet long, for the purpose of keeping the snow out. It will be furnished with a door, so that if necessary it can be loaded with iron.

The monster will weigh fifty tons, and will be operated by three of the heaviest engines on the road. The cost will be over $5,000. The machine was designed by Mr. G. E. Stevens, Superintendent of the car and building department, and Mr. J. H. Congdon, general master mechanic of the road.

An Adjustable Multiplying Mirror.—The engraving herewith presented represents an arrangement of mirrors, designed and patented by Mr. Bielefeld, the well known optician of Philadelphia.



The engraving, which is a slight reduction of the instrument, shows two metallic plates with inner surfaces silvered, and highly polished. These are arranged to open and close, having a movement of 90°, by means of a hinge shown at the top. This is formed by the appropriate folding upon each other of a small extension of each of the plates, and securing the same with a rivet. The upper surface of the hinge is flat, and upon the lower of the two is brought a graduation from zero to 90°, while the extremity of the upper fold is fashioned into an index, which, upon moving the mirrors, travels over the graduated arc, and indicates their angular aperture.

It will be apparent that we have here an instrument by which an object placed between the mirrors will be multiplied any desired number of times. When placed at right angles, the mirrors will show, besides the object, three images or reflections of it; at 60°, besides the object, five images; at 45°, seven images, etc.—thus combining the kaleidoscopic effect, with the means of varying the appearance and

intricacy of combinations, derivable from one and the same design as a basis.

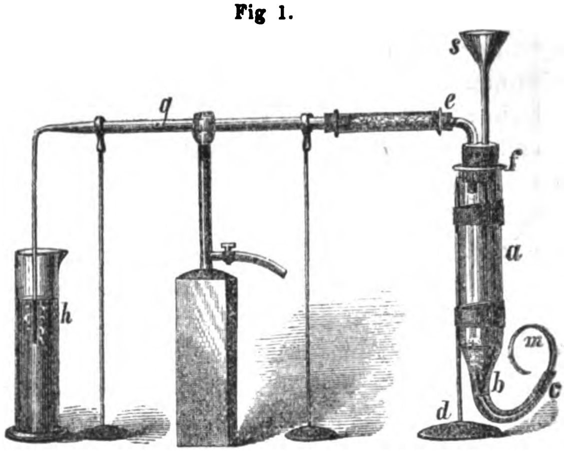
The inventor has intended the instrument to be of service to designers of patterns for textile fabrics, etc.; for artists, draughtsmen as well as a useful adjunct for instruction in schools.

There can be no question that for the first of these uses, the facility with which a happy pattern can be modified indefinitely by the adjustable property of this device, will prove of much convenience and advantage; while, as a scientific toy, the beauty of its effects, and its portability, will doubtless render it popular.

Improvements in the Mode of Arsenic Analysis.—Prof. John C. Draper has communicated to several of our contemporaries an article containing some very valuable suggestions concerning the modes of determining arsenic in medico-legal investigations. The suggested improvements are upon the method usually employed, namely, the precipitation of metallic arsenic from its gaseous compound with hydrogen.

Recognizing the great difficulty of securing pure zinc for the purpose of the Marsh test, the author has suggested the substitution for it of magnesium. For this purpose he has somewhat modified the apparatus usually employed, and constructs it as shown in fig. 1, in which the generating vessel is formed of a glass tube, drawn out tolerably thin at its lower part. This is curved upwards, as shown, and the bottom of the vessel covered to some height with mercury, which will, of course, sustain the higher column of acid subsequently added in the tube. At *e* is a drying tube; and at *g*, the reduction tube; while any arsenic escaping reduction with the lamp in this,

Fig 1.

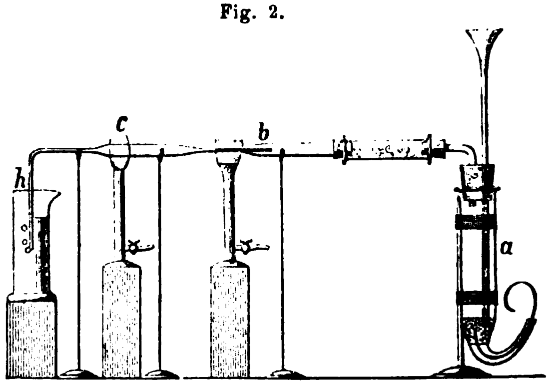


is caught up in the flask *h*, beyond which contains some nitrate of silver.

The operation of the device is as follows: The magnesium, in form of a band, is fed up into the tube *a*, by hand, through the quicksilver, as rapidly or slowly as may be required by the energy of the gas evolution; and the resulting gas is tested by the reduction flame for considerable time, in order to assure a confidence in the purity of the reagents employed. After this has been determined, the suspected liquid is fed in, in known quantity, through the funnel *s*, and the reduction test effected.

As, in most cases of arsenical poisoning, it is desirable to obtain all the arsenic found in an organ of the body, at one spot, in order that it may be first accurately weighed before being subjected to the action of subsequent tests, the author has arranged for the introduction into the reduction tube of a faggot or bundle of platinum wire. Upon these wires the whole of the arsenic, if any be present, is deposited. Fig. 2.

Fig. 2.

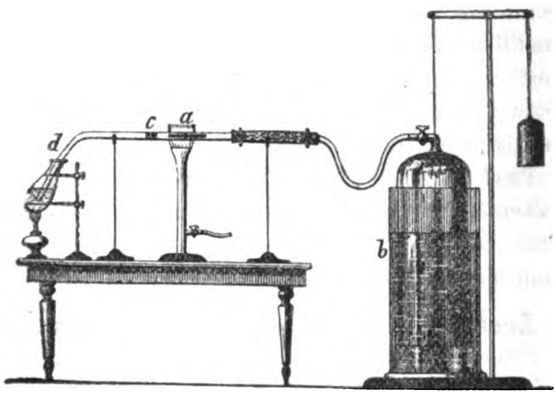


It consists of a hard lime glass tube drawn down at *b* to one-tenth of an inch, into this fine space are dropped a weighed quantity of fine platinum wire, which should fit closely in the manner shown in cut. The end of the tube, *h*, dips into a vessel of nitrate of silver. The position of the gas-burners will need no further explanation. After the introduction of acid into the generating vessel and the preliminary test for the purity of the materials employed, the suspected liquid is introduced as before and the test proceeded with; when, if arsenic is present, it will all be found upon the platinum, and its weight determined by the gain in weight of the platinum faggot which is removed from the tube for this purpose. The vessel of nitrate of silver is for the same purpose as that in the previous case.

Fig. 3 shows the device employed to remove the metallic arsenic from

the platinum and to convert it into arsenious acid, for the purpose of subjecting it to further tests as to its identity.

Fig. 3.



The faggot of platinum is placed in a tube of the form shown at *a c d*, and heated by the gas flame, while at the same time a current of dry oxygen gas is passed over it from the gasometer, which is shown attached. By this means all the arsenic is volatilized from the metal at a dull red heat, and recondenses as arsenious acid at a point, *c*, beyond the flame. The small portion which escapes condensation here may be caught by leading the open end of the tube into water kept moderately boiling at *d*.

We believe the device, here very briefly described, possesses quite a number of points of advantage, both in its freedom from several of the drawbacks incident upon the ordinary method employed, and in its neatness and convenience of form. It seems to be in every way worthy of recommendation to the analytical chemist as a standard piece of apparatus for the purpose for which its experienced designer has intended it.*

An Improved Filter Pump.—Dr. Mendelejef recently described, before the Chemical Society of Berlin, a modification of the Bunsen filter pump, which, besides rendering this laboratory adjunct portable, also greatly adds to its simplicity and serviceability. The gist of the improvement consists in bringing, at the junction of the water-pipe with the branch tube connecting with the vessel to be exhausted, a valve devised originally by Bunsen, and known to chemists as Bunsen's valve. By this means the necessity for a considerable fall of water is done away with, as well as the elaborate length of pipe, since so soon as the water is turned on the valve commences to pulsate, opening and closing with rapidity, thus reproducing, to perfection, the action of the hydraulic ram. The pump may be operated

* For the illustrations to this item we are indebted to the courtesy of the Editors of the *American Chemist*.—Ed.

with a fall of a few inches of water, instead of 30 feet, as before essential to secure good exhaustion, and to perform its work with great readiness and completeness. Prof. T. E. Thorpe has still further modified the apparatus by constructing the valve of a metallic funnel, perforated with openings. In this funnel is firmly attached a tightly fitting caoutchouc sheet, which operates with the same ease as above, and is much more durable.

Prof. E. A. Smith, of Alabama, who is, as far as our knowledge extends, the first in this country to introduce this improvement, states that its operation is eminently satisfactory, giving, with but a few inches of fall, very good exhaustion.

Lecture Illustrations of Fluorescence.—In a lecture on "Fluorescent Light," recently delivered in the Academy of Music, Philadelphia, President Morton, of Hoboken, exhibited some very remarkable and altogether new experiments.

A large screen, of a pale yellow color, was lowered from the upper regions of the stage, and, as the lecturer expressed it, was interrogated, in the way of experiment, as to what property it possessed, by various colors of light. A brilliant yellow, a green, and a red light, were successively thrown upon it from an electric lamp, but it remained unchanged and made no sign. Then a violet light from the same source, streaming over the word "Fluorescence," flashing out upon the screen in immense letters of luminous green, at once answered the question and illustrated the property. So, again, a gigantic flower, painted in pale monochrome, gleamed out in varied and vivid tints, under a like treatment. In another place, the lecturer alluded to the invisible rays present in the solar beam and light from other sources, which, though inappreciable to the eye, are very active, in photography, and then did what has certainly never before been accomplished—showed these rays, on a fluorescent screen, to the immense audience assembled to hear him. The invisible spectra of copper, silver, zinc, etc., were thus projected and compared.

The substance employed in the superb experiments named above was the new material, Thallene, described in the "Journal" several months ago.

The Oxygen Light.—At the recent Industrial Exhibition of the American Institute, the large hall devoted to this purpose was illuminated upon the plan devised by M. Tessié du Mothay, which has received occasional notices in the "Journal."

Quite recently a brief account of the report of a commission of

experts appointed by the French government was published amongst our items, in which the light was pronounced to be unsuited for street illumination, from the complication of the process and its considerable expense; at the same time, however, it was commended as an excellent one for interior illumination. The results of its trial in the building of the late exhibition seems to have fully confirmed this view of the French experts; since, if we may judge from the enthusiastic comments of the New York press, it has received unlimited praise, from its unusual purity and brilliancy. From the same sources we have it commended as a street illuminant; but, though there can be no question as to its superiority in every quality which an illuminant should possess, we believe that our contemporaries have underrated the objections urged against it for such an application, since in Paris, where it has received an extended trial, it has been removed from the boulevards to give place to the ordinary gas-lamps, which it was designed to substitute.

Government Aid to Science.—In the recent report of the Secretary of War, are contained the following remarks upon the highly important subject of securing government aid in prosecuting an extended series of experiments upon steam-boilers, for the purpose of ascertaining, under the most varied conditions, the cause or causes of explosions, and of determining the remedy:

The universal employment of steam at the present day in naval as well as commercial operations, renders this a matter of extreme interest to all, and one demanding the serious attention of the government. In December last, at the suggestion of private parties who were about to institute some experiments upon actual boilers at Sandy Hook, I appointed a board of engineers to attend and witness the result Appended hereto is a copy of their report, which seems to indicate that much valuable information and perhaps a solution of the difficult problem may attend a further prosecution of the inquiry. Indeed, the information already acquired is deemed by those competent to judge, of much interest and importance. It is gratifying to know that the experiments which have led to the most reliable information hitherto possessed by the scientific world on this difficult subject, were instituted and conducted by an American institution (the Franklin Institute, of Pennsylvania), under the patronage of our government, over thirty years ago. Those experiments were detailed in two able reports, one made in January, 1836, on the manifestations of steam under various conditions, and its effects, as steam, upon a small model boiler constructed for the purpose; and the other, made some months afterwards on the strength of materials employed in the construction of steam-boilers. The former report was published in Ex. Doc. No. 162, first session, Twenty-fourth Congress; the latter in Ex. Doc. No. 18, second session, Thir-

tieth Congress, included in a special report of the Commissioner of Patents. It is to be regretted that the experiments thus auspiciously commenced had not been continued until a complete solution of the difficulties could have been obtained. No material advance seems to have been made in real knowledge on the subject since that time, and the great desideratum at the present day is a series of well-directed experiments on actual boilers used in navigation.

It was the employment of such boilers in the experiments made last season, at Sandy Hook, which was the means of producing the interesting results before alluded to. But the making of experiments on this scale is attended with too much expense and risk of capital to be carried on by private enterprise. It can only be accomplished under the patronage of the Government, and it seems to me that any reasonable outlay in this direction would be amply repaid in the increased security to our naval and commercial marine Legislative regulation of the inspection and management of steam boilers must necessarily be imperfect under an imperfect knowledge of the causes which lead to explosions; and reliable knowledge can never be attained by silent reflection in the study, or by verbal and theoretical discussion, but only by actual trials on real boilers, under such conditions and circumstances as the present advanced state of engineering science and skill shall dictate. This Department has noticed with much interest that the subject has engaged the attention of Congress, and that a law has passed one House at its late session, providing for a continuation of experiments such as have been recommended. There are few things at this time, affecting the commercial and naval interests of the country, of more practical importance than this, and it is to be hoped that the pressure of business at the coming session will not cause the matter to be overlooked.

Continuous Chlorine Process.—The following is a brief description of a process for this purpose, invented by Tessié du Mothay, which has been the subject of much criticism on the part of our foreign contemporaries. The design of the invention is to manufacture chlorine continuously from a given supply of manganese.

Into a retort containing black oxide of manganese, or a mixture of this substance and lime, and heated to a dark redness, he passes a stream of muriatic acid gas. Chlorine gas and watery vapor are given off, while protoxide of manganese and chloride of calcium remain in the retort. The chlorine may be collected in water if required, or passed into chambers for the preparation of bleaching lime.

Over this remaining mixture in the retort he passes, at the same temperature, a stream of atmospheric air, when the chlorine in the chloride of calcium and chloride of manganese is set free. This stream of chlorine, mixed with atmospheric air, or with variable proportions of nitrogen and oxygen, is led into large stone-ware receivers, containing a mixture of lime and oxide of manganese, previously prepared by decomposing chloride of manganese with an excess of lime

and pouring off the solution of chloride of calcium thus obtained from the oxide of manganese deposited.

In presence of atmospheric air and of chlorine, there is formation of peroxide of manganese and hypochlorous acid, which latter combines with the lime, forming bleaching-lime. This mixture, of hydrated peroxide of manganese, chloride of calcium, and bleaching-lime, is treated with liquid muriatic acid. Thereon chlorine escapes, which is led into the chambers for the preparation of bleaching-lime. In the stone-ware receivers, there remains a mixture of chloride of manganese and chloride of calcium, which is treated afresh with excess of lime, yielding again the above-mentioned mixture of oxide of manganese, lime, and chloride of calcium. The solution of chloride of calcium is run off, the other two ingredients remaining for future operations. By the action of a mixture of atmospheric air and chlorine upon them we again obtain peroxide of manganese, chloride of calcium and chloride of lime.

The chloride of calcium accumulating in these operations is mixed in tanks with carbonate or hydrate of magnesia, when we obtain carbonate of lime (or hydrate) and chloride of magnesium. The latter on distillation gives off hydrochloric acid, which can be again used in the preparation of a further quantity of chlorine. The magnesian residue in the retorts serves for the decomposition of a fresh accumulation of chloride of calcium.

Honor to Inventors.—We have received, through the courtesy of Dr. George Haseltine, of London, the following slip, which is at present going the round of the English press. Its object is so eminently appropriate and deserved, that it will not fail in attracting interest.

"Inventors are a class—*sui generis*—and their rewards, in lifetime, are mostly *nil*, their honors posthumous. They are, moreover, cosmopolitan, and in general their labors, when successful, benefit, not one class or nation alone, but mankind at large.

As it is therefore fitting that, in some shape or form, honor should be given where honor is due, we have learnt with much interest and pleasure that the Commissioners of the New York Central Park have allotted a portion of their domain for the erection of memorials to the inventors of all nations, and it is now proposed to erect one of these memorials in honor of Elias Howe, the inventor of the Sewing Machine.

The good fortune to confer equal benefits on mankind is reserved to few inventors, and while this invention is the world's common inheritance, a large share of the legacy has fallen to Englishmen, who have never yet been found wanting in gratitude to their benefactors. This object appeals directly to the sympathies of the inventive class, of which Mr. Howe was an illustrious representative; and there will, doubtless, besides be many a cheerful giver among the humble users of sewing machines.

The influential committee organised in America to provide the memorial funds will, we learn, be aided by a committee recently formed in this country, which comprises a number of well-known gentlemen, and the co-operation of a number of technical societies has also been obtained. The estimated cost of the memorial is fifty thousand dollars—ten thousand pounds—and a unique design has been submitted to the committee by an eminent sculptor, a personal friend of the inventor. The composition of the committee indicates a very general interest in the movement, and is an earnest of its success. Truly the victories of peace are greater than the victories of war, and the due and fitting recognition and veneration of the heroes of these beneficent victories is at once the ornament and illustration of modern civilization."

Editorial Correspondence.

Dr. Wm. H. Wahl:

DEAR SIR,—As your Journal publishes all the scientific novelties, I send you a notice of a curious experiment I saw to-day at our City College. I had called there to see the effect of some suggestions I had made to Dr. Wilkinson (Prof. Doremus' assistant), for deodorizing kerosene oil, and amongst various trials he made the following:

He put a small quantity of permanganate of potash at the bottom of a beaker, then poured in some kerosene, and then added a small quantity of sulphuric acid. Nascent oxygen was immediately generated and *took fire*, with slight explosions as it bubbled through the oil. A little water added seemed to cause a more vigorous display of flashes.

Respectfully yours,

ROBT. W. NEWBERRY.

New York City, Nov. 19th, 1872.

Civil and Mechanical Engineering.

TRACTION ENGINES OR ROAD LOCOMOTIVES.*

THE PAST, THE PRESENT AND THE FUTURE OF STEAM ON THE COMMON ROAD.

By Professor R. H. Thurston.

When, during the last century, the steam engine had so far been perfected that the possibility of its application to other purposes than the elevation of water had become generally recognized, the problem of its adaptation to the propulsion of carriages was attacked by many engineers and inventors.

As early as 1759, Dr. Robison, who was at the time a graduate of the University of Glasgow, and an applicant for an Assistant Professorship there, and who had made the acquaintance of the instrument maker, James Watts, when visiting the workshop, called the attention of the latter, who was probably then more ignorant of the principles of the steam engine than was the young student, to the possibility of constructing a carriage to be driven by a steam engine, thus, perhaps, setting in operation that train of thoughtful experiment which finally earned for Watt his splendid fame.

In 1765, that singular genius, Dr. Erasmus Darwin, whose celebrity was acquired by speculations in poetry and philosophy as well as in medicine, urged Matthew Boulton, -subsequently Watt's partner, and just then corresponding with our own Franklin in relation to the use of steam power,—to construct a steam carriage or "fiery chariot," as he poetically styled it, and of which he sketched a set of plans.

A young man, named Edgeworth, became interested in the scheme, and, in 1768, published a paper which had secured for him a gold medal from the Society of Arts. In this paper, he proposed railroads on which the carriages were to be drawn by horses, *or by ropes from steam-winding engines.*

These were merely promising schemes, however. The first actual experiment was made, as is supposed, by a French army officer, Nicholas Joseph Cugnot, who, in 1769, built a steam carriage which was set at work in presence of the French Minister of War, the Duke de Choiseul. The funds required by him were furnished by the

* Read before the Polytechnic Club of the American Institute.

Compte de Saxe. Encouraged by the partial success of the first locomotive, Cugnot, in 1770, constructed a second which is still preserved in the '*Conservatoire des Arts et Metiers*,' Paris.

Watt patented a road engine in 1784, after he had made the more essential improvements in general design and in the details of his pumping engine. At about the same time, Murdoch, his efficient lieutenant, completed and made a trial of a model locomotive, driven by a "grasshopper engine," having a steam cylinder three-quarters of an inch in diameter and two inches stroke of piston. It is reported to have run six to eight miles an hour, its little driving wheels making from two hundred to two hundred and seventy-five revolutions per minute.

In 1786, Oliver Evans asked of the Pennsylvania Legislature the monopoly of his method of applying the steam engine in driving flour mills *and to propelling wagons*. In the same or following year, Wm. Symington constructed a working model of a steam carriage, which may still be seen in the Patent Museum at South Kensington, London.

In 1802, Trevithick and Vivian took out a British patent for a locomotive engine, and their model is also preserved in the Museum of the British Patent Office.

In 1804, Oliver Evans completed a flat-bottomed boat to be used at the Philadelphia docks, and, mounting it on wheels, drove it by its own steam engine to the river bank. Launching the craft, he propelled it down the river, using its steam engine to drive its paddle-wheels. Evans' "*Oructor Amphibolis*," as he named the odd machine, was the first road locomotive that we find described after Cugnot's time.

Evans assured incredulous legislators that carriages propelled by steam would soon be in common use, and offered a wager of three hundred dollars that he could build a "steam wagon" that should excel in speed the swiftest horse that could be matched against it.

In 1821, Julius Griffiths of Middlesex, England, made a steam carriage for common roads, which he designed to carry passengers, and which was probably the first ever constructed for that purpose only.

During the succeeding ten or fifteen years, Messrs. Burstall & Hill of London and Edinburgh, Mr. Goldsworthy Gurney, the Messrs. Seaward, W. H. James, Walter Hancock, Ogle & Summers, Sir Chas. Dance, and others in Great Britain, and Harrison Dyer, Joseph Dixon, Rufus Porter and a Mr. James, in the United States, with, probably, many others whose names are unknown in history, attacked this important and seductive problem with varying success.

In December, 1833, about twenty steam carriages and traction road engines were running, or were in course of construction in and near London.

In our own country, the roughness of roads discouraged inventors, and, in Great Britain even, the successful introduction of road locomotives, which seemed at one time almost an accomplished fact, finally met with so many obstacles that even Hancock, the most ingenious, persistent and successful constructor, gave up in despair. Hostile legislation procured by opposing interests and, possibly also, the rapid progress of steam locomotion on railroads caused this result.

In consequence of this interruption of experiment, almost nothing was done during the succeeding quarter of a century, and it is only within a few years that anything like a business success has been founded upon the construction of road locomotives, although the scheme seems to have been at no time entirely given up.

J. Scott Russell, Boydell, and a few others in England, and Messrs. Roper, Dudgeon, Fawkes, Latta, and J. K. Fisher, in the United States, have all, at various times labored in this direction.

The last-named engineer designed his first steam carriage in 1840, and is still at work.

Abroad, a few firms have succeeded, within a few years past, in making a business of considerable extent in constructing road locomotives for hauling heavy loads, and in building steam road rollers.

While steam carriages of high speed, and adapted to the transportation of passengers, have not yet been successfully introduced, a most promising start has been made in the application of steam to the heaver kinds of work on the common road.

The great impediments seem to be the roughness and bad construction of the ordinary highway, the damages arising from the taking fright of horses, the engineering difficulties of construction and the limited power of the machine as it has usually been built. Hostile legislation might perhaps be placed in the category, but we are probably sufficiently far advanced in civilization to-day to be able to secure liberal legislation when the people shall be satisfied that the introduction of the road locomotive will be of great public advantage.

The capabilities of the road locomotive are readily determined by experiment, and the following paper embodies the results of several series of trials.

When in Great Britain, some two years ago, the writer found that

the construction of traction engines and steam road rollers was occupying the attention, to a considerable degree, of several engineering firms, among whom may be mentioned Messrs. Aveling & Porter, Tuxford & Sons, Burrell, Ransomes Sims & Head and others.—Messrs. Fowler & Co. were constructing machines to be used in steam ploughing, an application of steam to which they were giving especial attention.

The first-named firm seemed a leading one in the business of building road locomotives, and about 400 workmen were kept employed by them. Their engines seemed well built and had an excellent reputation, but, unfortunately, the short time available merely permitted an inspection of their machines, and no opportunity offered to witness a prearranged trial, or even to see them at ordinary work.

More than two years previous to the period just referred to, a trial of these machines was made by the well known French engineer, Mon. H. Tresca. *Sous-directeur du Conservatoire Imperial des Arts et Metiers*, Paris, and in presence of the equally distinguished English Professor, Fleemin Jenkin. The report was submitted to the *Directeur*, General Morin, January 15th, 1868.*

The results may be summarized as follows:

1. The coëfficient of traction was determined to be about 0·25 on a good road with easy grades.

2. The consumption of coal was found to be 4·4 pounds per horsepower per hour.

3. The consumption of water was determined to be 132·2 gallons an hour with the "ten-horse" engine.

4. The "coëfficient of adherence," or of friction between the wheels and the soil was 0·3.

5. A rate of motion of seven miles an hour produced no special difficulty in managing either the locomotive or its load.

This engine was of large size, having a steam cylinder of 11 inches diameter and a stroke of piston 14 inches. The crank shaft was geared to the driving-wheels in such manner as to make 20·33 or 14·25 revolutions, at pleasure, for each revolution of the drivers. The driving-wheels were 6½ feet in diameter, and the weight of the machine, exclusive of fuel and water in its tank, was fourteen and one-half tons. Including fuel and water its weight was seventeen

***Proces-verbal des Experiences faites sur une machine de traction; Conservatoire des Arts et Metiers*; Paris; 1868.

and one-half tons. The load drawn on a level road was 79 tons, 19 cwt., 1 qr., (77,597 kilo's), including the weight of the machine itself. This weight was distributed as follows:

Weight of engine, . .	21·8 *per centum* of total.	
" wagons, . .	25·9 " "	
" paying load, .	52·3 " "	
	100·	

In addenda to the report of M. Tresca it is stated that M. Lalouette had set the engine at work transporting heavy material, and with the following results:

It transported a total weight of 2,500,000 kilogrammes a distance of 4 kilometres, drawing, on each trip, 25,000 kilogrammes of paying load, and making four trips per day. Five hundred kilogrammes of coal were consumed in eight journeys.

At about this same time, M. Servel, *Ingenieur en chef de la Compagnie Générale des Messageries à Vapeur*, conducted a series of experiments with a similar machine upon paved and upon macadamized roads, during what he describes as the most trying of winter weather. Under such unfavorable conditions, M. Servel reports the following distribution of weights by *per centum*:

Weight of locomotives, . . .	41.4
" wagons, . . .	18·2
" paying load, . . .	40·4
	100·

The average total weight of three loaded wagons, which was the usual load, was 22,575 kilogrammes, or very nearly 22 tons.

The experiment was made in 1867—'8 of applying these engines to the towage of boats on the French canals. The results seem to have been very encouraging. M. Géraldi reported that an 8-horse engine towed on the canal between Caen and Oyestreham, a fleet, having an aggregate measure of 800 tons, at the rate of three miles an hour, and that the speed had been pushed, on occasion, up to six miles an hour. The latter speed was not considered an advisable one, however.

M. Carfort reported to M. Huet that a 6-horse engine, doing similar work on the Dunkerque and Saint Omer canal, had towed 800 tons and was regularly towing 500 to 700 tons at an expense not exceeding 40 per centum of the cost of horse power.

In the year 1871 a number of traction engines were exhibited before the Royal Agricultural Society of England at their show at Wolverhampton, and the judges appointed by the Society made a series of exceedingly interesting and instructive tests.*

The judges state in their report that on a road in good order wheels fitted with India-rubber tires, as patented by Thompson, have an advantage over iron rigid wheels in tractive force, but that the cost of such wheels—fifty per centum of the cost of the locomotive—forms a most serious obstacle to their adoption; still they "are not prepared to express a decided opinion" upon that subject. On farm roads and in fields the India-rubber tires "signally failed." Plain iron wheels, with "paddles" attached, succeeded where the former failed.

A 10-horse locomotive entered by Messrs. Aveling & Porter received the first prize at the termination of these trials; two competing systems of rubber tires—those of Thompson and of Adams—were each awarded a silver medal; a 6-horse power road locomotive by Aveling & Porter, and an 8-horse power road engine by Burrell, were very highly commended.

The prize engine had a cylinder of 10 inches diameter and a stroke of piston of 12 inches, a fire grate area of 6½ square feet, an area of heating surface of 204·4 feet, driving-wheels 6 feet in diameter, and 18 inches breadth of face. These wheels made one revolution to 17 of the crank shaft. The total weight of the engine was 12 tons, of which 8¾ were on the driving-wheels. The coal used, on special trial, amounted to 3·2 pounds per indicated horse power per hour, and the evaporation of water was 7·62 pounds per pound of coal consumed, the average temperature of feed being 175° Fahrenheit.

The load drawn up the maximum grade of 264 feet to the mile on Tettenham hill, which is 1900 feet from top to bottom, was 26 tons, or, including weight of engine, 38 tons, giving a coëfficient of traction of 0·35.

On a country road, 16 miles long, it drew 15 tons at an average rate of speed of 3⅓ miles per hour, using 2·85 pounds of coal and 1·94 gallons of water per ton of useful load per mile.

On farm soil, soaked with recent rains, the load drawn was 9 tons, and speed something less than an average of two miles per hour, using 13·6 pounds of coal per ton of paying load per mile. This engine was fitted with smooth-tired driving-wheels.

* Journal of the Royal Agricultural Society of England, Vol. VII; London: J. Murray, 1871.

In July, 1871, another trial was made in the same vicinity at the request of officials of the British War Department, during which a 6-horse engine, by the same builders, drew 7 tons, 12 cwt., up a hill having a maximum grade of one in 7·33, or more than 600 feet to the mile.*

In September of the same year still another trial of the same, or a duplicate engine, occurred between Rochester and Chatham, in which the same style of driving-wheel was used as in the trials at South Orange, N. J., to be hereafter described.

Star Hill was ascended by this engine, the maximum grade being 480 feet to the mile. This performance is compared by *Engineering* with that of a road steamer fitted with India-rubber tires, which was tried earlier at Tettenham. The first named engine drew 2·94 times its own weight, and its competitor hauled 2·5 times its weight on maximum grades of 1 in 11 and 1 in 18, respectively—excellent performances both. The rigid wheel in this case seems to have had considerably greater pulling power than that fitted with elastic tires.

The authorities already quoted furnish valuable information as to the capabilities of this system, but the writer, in common with many others of the profession, has long been desirous of learning more of its value on good roads by personal observation. Fully believing in the ultimate and general adoption of steam traction on our streets and roads, it yet seemed a question whether there might not exist some unanticipated obstruction, or some serious difficulty not referred to in published reports.

The desired opportunity recently presented itself when the writer was requested to conduct a public trial of the road locomotives of Messrs. Aveling & Porter, and of their steam road rollers, and was proffered every desired facility for making a thorough examination of the construction of the machines, and for testing their powers of traction and manœuvring. Mr. W. C. Oastler, agent for the builders, promised to furnish one locomotive, and Mr. Daniel Brennan, Jr., President of the Telford Pavement Co., of Orange, N. J., offered a road locomotive and a steam roller, with the privilege of taking as a trial ground any portion of the macadamized road which the company were constructing at South Orange.

Engagements permitting, a day, Saturday, September 21st, was taken for a visit to Orange to inspect the engines and to select a trial ground. The trial was to take place October 1st, and invitations were

* London Engineering, July 14, 1871.

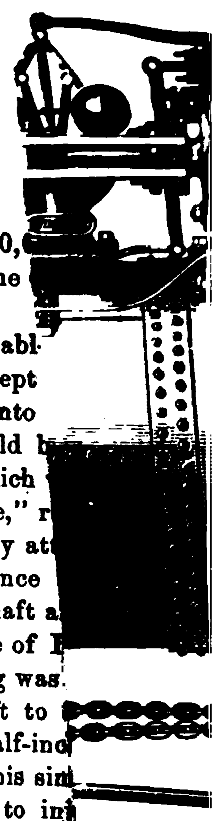
extended to and accepted by the Commissioners of P
Essex and for other Counties of New Jersey, and by m
engineers of New York and vicinity.

Two road steamers or traction engines and a steam r
brought out for exhibition and trial.

No. 1 was a new road locomotive built by Messrs. Ave
it had previously done no real work. A sketch of t
shown in Figure 1.

The following are the principal dimensions:

Weight of engine, complete, 5 tons, 4 cwt., . 1
Steam cylinder—diameter in inches, .
Stroke of piston—inches, . . .
Revolution of crank to one of driving-wheels,
Driving-wheels—diameter in inches, . .
" —breadth of tire in inches,
" —weight, pounds each, .
Boiler—length over all, feet, . .
" —diameter of shell, inches, . .
" —thickness of shell, inches, . .
" —firebox sheets, outside, thickness in inches,
Load on driving-wheels, 4 tons, 10 cwt., pounds, 10,

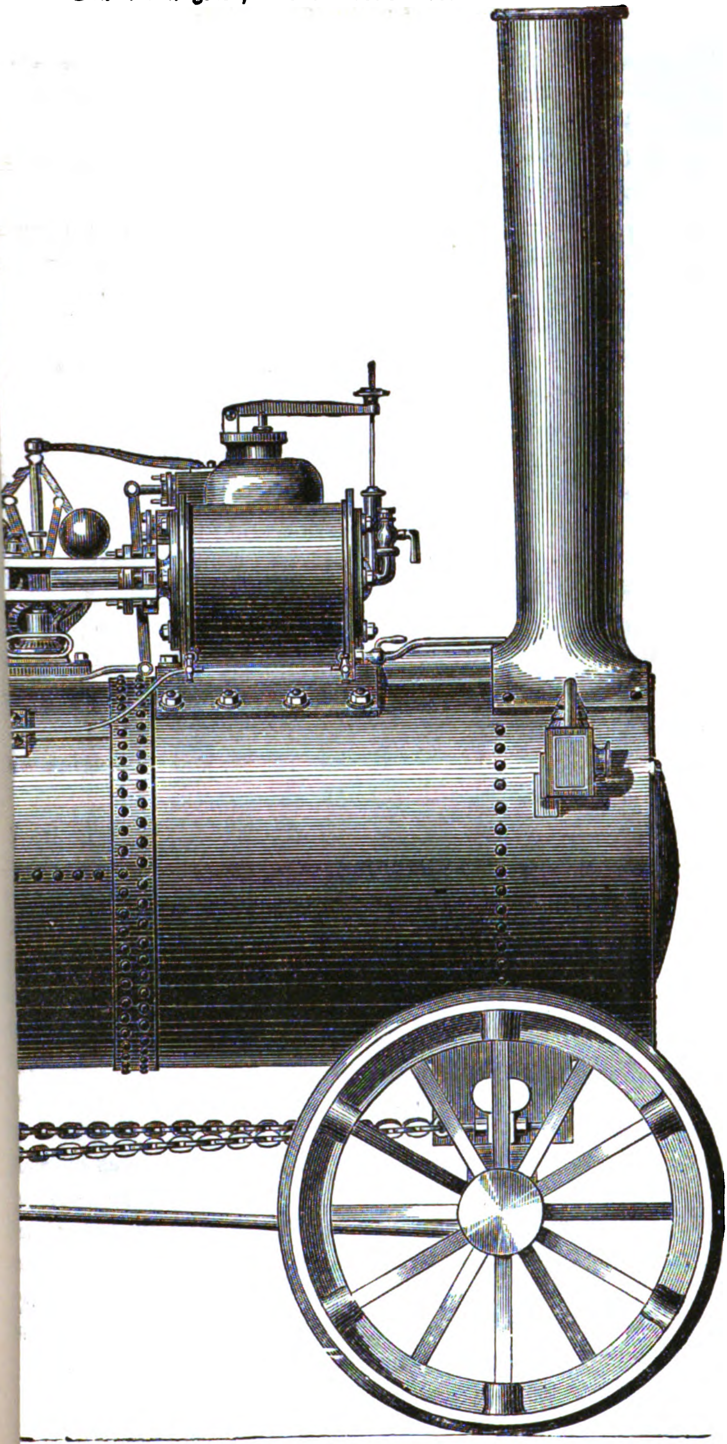


The boiler was of the ordinary locomotive type, and the
mounted upon it, as is usual with portable engines.

The driving pinion on the crank shaft was made capabl
slipped out of gear, thus allowing the engine to be kept
when the locomotive was at rest, either to pump water into
or to drive as a "portable engine," by a belt which could b
on the pulley, 4½ feet in diameter and 5 inches face, which
to act as a fly-wheel. When used as a "portable engine," r
was effected by means of a fly ball governor conveniently at

The steam cylinder was steam jacketted in accordance
most advanced practice here and abroad. The crank shaft a
wrought iron parts subjected to heavy strains were made of
iron and were strong and plainly finished. The gearing was
leableized cast iron, and all bearings, from crank-shaft to
wheel, on each side, were carried by a single sheet of half-in
which also formed the sides of the fire-box exterior. This si
admirable device united all parts, peculiarly exposed to in
jarring, with such firmness as would seem to give almost a
security against such injury on even very rough roads. See Fi

Traction Engines, or Road Locomotives.

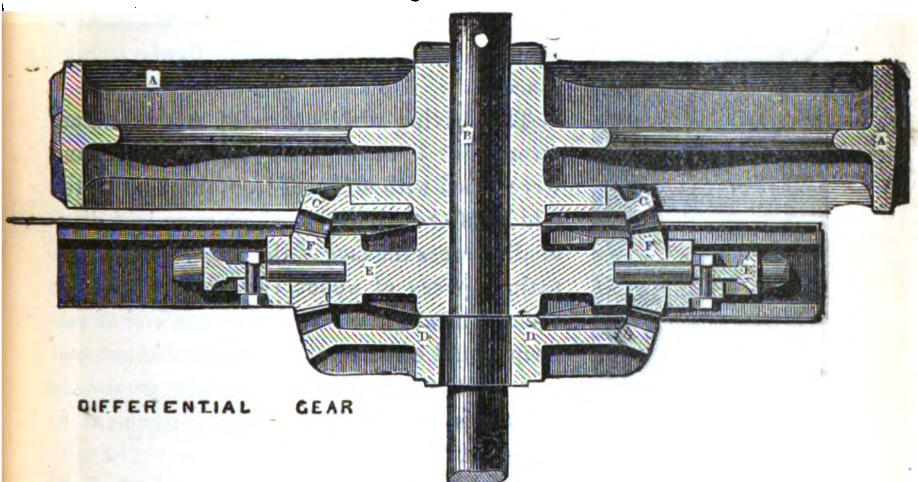


...g & Porter.

The engine valve gear consisted of the standard arrangement of three ported valve and Stephenson link with reversing lever, so generally used on locomotives. The feed pump, 1⅝ inches in diameter and 3½ inches stroke of plunger, was driven by an eccentric keyed on the crank-shaft.

The connection between the gearing and the driving-wheels was effected by one of the neatest and most ingenious devices known to engineers. This arrangement is called by builders of cotton machinery a "Jack-in-the-box" gear, and is shown in Fig. 2 as the "differential gear:"

Fig. 2.



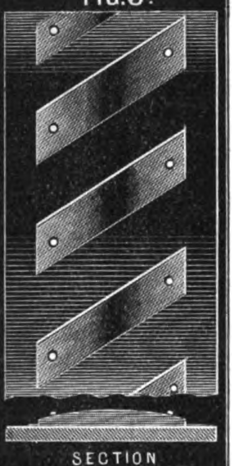
As constructed, and as shown in the figure, one wheel (A) turns freely on the driving-axle at B, while the other driving wheel is keyed fast. The latter is not shown in the cut. A bevel gear (C) is bolted on the hub of the wheel (A), and a similar gear (D) is keyed to the driving-axle. Between these revolves a spur gear (E), which is driven by the engine, and which carries two small bevel pinions (FF), the latter engaging both bevel wheels, C and D, their axles being in the plane of revolution of the large gear (E).

An examination of the combination will show that, resistances being equal on both wheels, if the spur gear (E) be turned, it will carry with it both driving-wheels at the same time with equal angular velocities, the effort exerted by the engine being equal at both wheels at all times.

If the engine be turning a corner, however, the greater resistance

on the inside wheel retards that, while the outer wheel necessarily moves more rapidly over its longer path, and, while the engine still exerts the same force on both wheels, the work done is distributed unequally between them through the then revolving bevel pinions, without loss and without either wheel being necessarily slipped or disengaged. Should one wheel, however, strike into a soft spot, as a patch of muddy soil, and finding so little resistance as to turn freely, leaving the opposite wheel at rest on firmer soil and thus checking the motion of the locomotive, a heavy bolt, which is furnished with each machine ready fitted to its place, is inserted and keys the loose wheel to the shaft. Both wheels must then turn together until, the locomotive being extricated, the bolt is withdrawn. Such an occurrence is seldom likely to take place.

FIG. 3.



SECTION

The driving-wheels were of wrought iron, strong but light in their construction, and were fitted with strips of iron, thickest at the middle of their lengths, which were laid diagonally across the face of the wheels, with separating spaces of about two inches between them. The angle was such that one end of one strip would come to a bearing on the ground just as the opposite end of the preceding strip was leaving it. This arrangement is shown in Fig. 3.

The builders claim that this method of obtaining tractive power in the wheel gives the engine a pulling power, on good ground, equal to 0.45 of the insistent weight,* while, with the smooth wheel used in the trial described in the report to the Royal Agricultural Society, quoted above, that coëfficient is but 0·25.

On extremely hard and smooth roads, bolts may be inserted in the wheel rim, whose heads give better holding power than even these

* This is equal to that obtained with the India-rubber tired wheel at Wolverhampton. A committee of the Royal (British) Engineers, consisting of Colonels Gallway, Wray and Lennox and Captain Home, compared the pulling power of these wheels with that of India-rubber tired wheels in November, 1870, using the same engine with both, on Star Hill, near Rochester. They found them to be equal, with equal insistent weights.

The writer regrets that he has no personal experience with which to compare these results.

iron strips, and on very soft ground the same bolts are used to secure to the rim of the wheel pieces of angle iron, called by the builders "paddles," which take a good hold upon on the more unstable kinds of soil.

The weight of this locomotive rested principally upon the driving-wheels; about fifteen per centum was left upon the forward axle to insure good steering power.

The total weight on the drivers was somewhat increased when pulling a load, usually, by the inclination of the line of traction downward from the pulling bolt to the point of attachment to the load.

The forward axle is fitted with wheels of 42 inches diameter and 8 inches face; it swings about a king-bolt which is secured above in a bracket secured to the under side of the boiler smoke-box and is steadied by a strong rod, connecting its lower end with the forward end of the fire-box.

Chains led from each end of the axle to a shaft carried on the forward end of the fire-box, around which they wound in such a manner that turning this shaft would swing the axle.

A hand steering wheel, conveniently arranged near the throttle and reversing handles, turned this shaft, being connected with it by means of a worm shaft and pinion.

A tank at the rear of the locomotive carried coal and water in its compartments, and afforded a standing place for the engine driver from which he could readily reach the various handles and guages.

Draught was secured by means of the exhaust, and, when desired, the latter could be turned into the water tank, thereby securing a double advantage, heating the feed water and rendering the engine noiseless.

The boiler and steam cylinder were both well protected against losses of heat by coverings of felt and lagging.

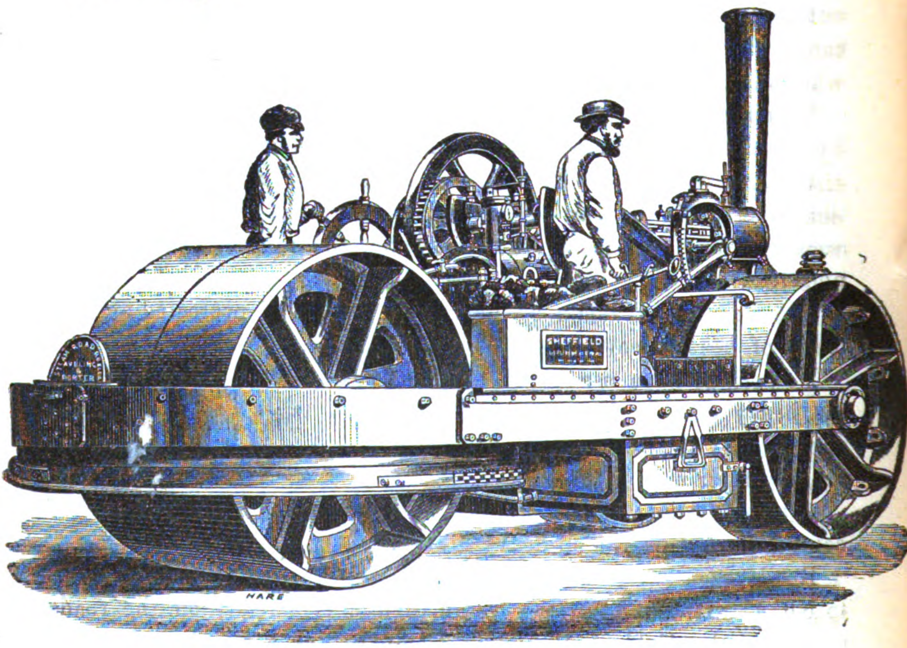
No springs were used on the engines exhibited as, being intended for heavy work at slow velocities, their advantages would not, it was supposed by the builders, justify the expense and complication attending their use.

A strap brake was fitted on the driving axle for the purpose of controlling the engine on heavy grades.

Road locomotive No. 2 was of the same size and of similar make to No. 1. It had been two years in use, or longer, on the roads made by the Telford Pavement Company, as a steam road-roller. To convert it into a road-roller, its ordinary driving-wheels had

been removed, and, in their place, were fitted a pair of cast-iron wheels, of similar diameter, but of 20 inches breadth of face, and weighing 3,800 pounds each. Their faces were left smooth, as hauling power was not desired, and as it was intended that they should leave the surface of the road as smooth and as firmly compacted as possible. In these driving-wheels, the engine carried an excess of weight of 6,700 pounds as compared with No. 1. In statements of work done, this excess should be entered as a part of the paying load where No. 2 is employed as a traction engine. The great weight of these wheels has an important effect in preventing the liability of slipping, which is a consequence of their smooth surface, and should bring up the equivalent coëfficient of adherence, in terms of the original weight of the engine, to about 0·42, or nearly equal to that of No. 1 with its regular traction wheels. As, during the trials about to be described, no slip was in any case observable, this difference would not in any way affect the results.

The weight of the steam road-roller offered for trial, everything included, was fifteen tons, or 33,600 pounds. This machine is represented in Fig. 4.



The engine and boiler were of the same general dimensions as the road locomotives already described. The furnace door was placed at one side of the fire-box, and the reversing lever, throttle handle and steam gauge were all brought to the same side, the engine driver standing on the frame of the machine, which is sufficiently broad and is immensely strong. The tanks for fuel and water were so placed as to be within reach of the driver. The steering apparatus was located at the side opposite the working gear of the engine, and was operated by the engine driver's assistant, who finds standing room on that side. The whole machine was carried on four large wheels, with broad tread, covering a total width of six feet. Its weight exerts a compressive force of 5,600 pounds on each foot of width, or 467 pounds on each inch.

The wheels had holes drilled in their faces, like the wheels of the traction engines, in which could be inserted strong spikes for breaking up old roads previous to making repairs, or for loosening the surface previous to metalling new roads.

Referring to Fig. 4, it will be noticed that the steering wheels are set close together, at the fire-box end of the machine, on an axle, the outer extremities of which are secured in boxes carried by a turntable. This, being turned by the steering apparatus, carries the wheels in either direction, as desired.

The driving wheels, in this design, are driven from a counter shaft by a strong flat link chain, leading around a chain wheel on that shaft, and driving a similar but larger wheel on the driving axle. The chain links are made of forged scrap, case hardened, and the pins were of steel. A brake on the driving axle was of sufficient power to control the roller on the heaviest grades.

The whole machine was evidently well proportioned, and of great strength and simplicity in details.

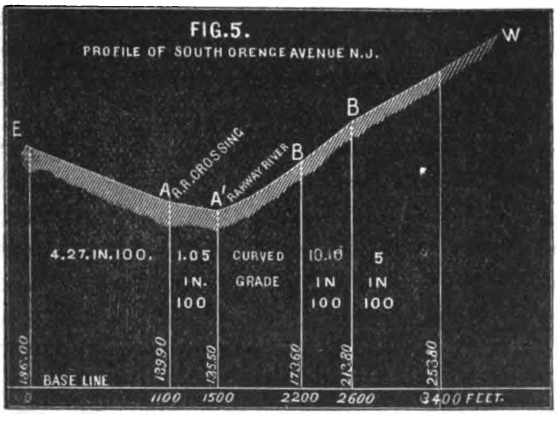
Preliminaries.—The preliminary examination of the proposed trial ground and its selection took place late in September, and a half day was devoted to an examination of the engines and of the road-bed. Engine No. 1 was found at Orange, and, after a careful examination had been made of its design and construction, the driver started with it over an awkwardly narrow and winding piece of road, traversing it without apparent difficulty, and going forward and backward at varying speeds, steering with evident ease and accuracy.

The writer then took the place of the driver, and, although the experience was a novel one, found no difficulty in acquiring, in a very

short time, such command of the machine that it became evident that but little training would be required to enable any ordinarily intelligent mechanic to manœuvre the locomotive on the most difficult road. The reversing handle, the throttle and the steering wheel were conveniently located and easily operated. Reversing could be performed promptly, notwithstanding the weight and consequent momentum of the fly-wheel, which, it had been apprehended, might cause loss of time, if not an excessive strain, when reversing suddenly. Steerage seemed almost equally easy and precise, whether going forward or backward. A block of wood, six or eight inches high, thrown under one forward wheel, was driven over without apparent difficulty or injury to the machine.

After these experiments and the examination of the locomotive were concluded, the party rode over to South Orange, where a portion of road containing heavy grades was selected for the public trial of the locomotives which have been described. It consisted of a short section of nearly level road, A A′ (Fig. 5), in the village of South Orange, near the railroad station, and of that part of the road, on either side of this nearly level stretch, which ascends from the valley by a moderately heavy grade, A E, on the eastern side, and by a very remarkably steep grade, A′W, on the western side. The profile, as given, was kindly furnished by the county engineer, Mr. Jas. Owen, of Newark, N. J.

FIG.5.
PROFILE OF SOUTH ORENGE AVENUE N.J.



This forms a portion of some fourteen miles of macadamized road, completed, during the past season, by the Telford Pavement Co., to whom No. 2 locomotive and the steam roller belonged.

The road-bed was remarkably smooth, hard and compact. It was constructed in the following manner: The original surface of the old road was first ploughed up and levelled off, the ploughing being done

by an immense plough, built for that purpose, and designed to be drawn by the road locomotive owned by the Pavement Company.

The surface is next carefully levelled up and brought to the required form, and is well rolled by the steam road-roller. The bed is then ready for the metalling. This consists of fragments of the very hard trap rock which lines the western bank of the Hudson river, near New York, and forms the Palisades, extending back from the river into the State of New Jersey.

The quarry is situated a short distance from the South Orange Railroad station, the county road leading directly past it. Steam drills are employed in holing, and the masses broken down by the blast are reduced by the quarrymen to a size which allows them to enter between the jaws of two Blake stone crushers, which are kept constantly at work preparing broken stone for the road. The whole plant is well placed and well arranged, and exhibits many interesting features which cannot be described here.

The heavier fragments are separated, by means of revolving screens, from the finer pieces and are used in forming the first layer of metalling. These heavy fragments, measuring from four to eight inches in their longest dimensions, are placed by hand, and the workmen settle them well in their place by striking them with a moderately heavy hammer.

Another layer of smaller material is used to cover that first laid down, and, upon this the steam road-roller is used until it is well compacted. As still finer material is added, the rolling is repeated until the surface becomes wonderfully hard and smooth. As a matter of course it must be extremely durable, even under heavy traffic. The trap rock used as metalling is one of the finest kinds of material to be found in our own or any other country, and the method of working it, here adopted, seems to be well adapted to securing the best results with it.

Such remarkably fine roads are, unfortunately, too seldom seen in this country, although not unfrequently met with in Great Britain and on the Continent of Europe. The fact is due partly, no doubt, to the infrequency of occurrence of such excellent material for metalling, but principally arises from the circumstance that very few boards of road commissioners are sufficiently interested in their work, and, at the same time, sufficiently energetic and far-sighted to indulge in what often seems extravagant expenditure, but what is really one of the most important among the means available for economizing greatly the cost of local and suburban transportation.

The road selected for the trials had been just made in the manner above described and seemed in excellent order, although the president of the company considered that it required considerably more rolling to make it what it was intended to be and in accordance with his specifications.

The trials were planned, and September 27th was the date fixed for them. That day proving stormy, they finally took place October 1st, in presence of a large number of gentlemen interested, professionally or otherwise, in the subject. The log was kept by student J. A. Henderson, of the class of 1873, Stevens Institute of Technology, to whose intelligence and zealous interest the writer is greatly indebted for the completeness of the record, as well as its accuracy.

First Trial.—The first trial was made at 10 o'clock, A. M., Oct. 1st, with Engine No. 1.

The load consisted of two wagons heavily laden with stone, and weighing, with their loads, 5000 and 5600 pounds, respectively—a total of 10600 pounds.

This load was drawn up a grade of 10·10 in 100—B. B. Fig. 5—equal to 533·28 feet per mile.

The wagon tires were very narrow and much worn, and were observed to cut into the roads somewhat, notwithstanding the thoroughness with which the road-roller had done its work.

The driver of the engine was a lad without experience. By putting coal in large pieces on his fire, at the worst portion of his route, he caused his steam pressure to fall rapidly, and was compelled to stop on the heavy grade until the pressure rose to 90 pounds again, when another start was made, and the top of the hill was reached without apparent difficulty.

Some annoyance was experienced from priming, partly in consequence of the low pressure maintained in the boiler, but principally, no doubt, because the boiler had not been in use long enough to thoroughly clean its interior surfaces. This engine was, therefore, detached, and No. 2, which had been long in use, was taken for the next trial over this same course.

Second Trial.—A trial was next made of the power of manœuvering possessed by these engines.

No. 1 was stationed at a part of the road which had not been rebuilt, and where the ground was soft and uneven. The machine turned *continuously* for a considerably time, in a circle of 18 feet radius, crossing the gutter at one part of the course, and gave no

evidence of difficulty arising from any cause. The engine could turn, when required, in a space slightly greater than its own length by carefully backing and filling.

THIRD TRIAL.—Locomotive No. 2, being attached to the same two wagons used in the first place, drew them up the hill to the summit without halting, and without priming or difficulty of any kind. The steam gauge indicated, at starting, 120 pounds, and at stopping, 90 pounds pressure of steam.

The time occupied in traversing 1450 feet was 3½ minutes; the speed being about 4⅗ miles per hour. Returning to the foot of the hill, a third wagon was brought up and attached, with the other two, to the same locomotive.

FOURTH TRIAL.—The total load in wagons was now 16530 pounds, and the excess in weight of the rolling wheels of this engine over the regular and, as already stated, more efficient traction driving wheels of No. 1, brought up the figure to a total of 23230 pounds.

This load was taken up the same heavy grade in four minutes,—almost precisely four miles an hour. The steam pressure varied from 105 to 120 pounds.

The action of the driving wheels was carefully observed, but no evidence of slip could be discovered, with even this last heavy load.

The proprietor and agent both desired to try again, using the same engine, with a fourth wagon added to the train, but time was passing rapidly and it was decided to change the ground, and to experiment with heavier loads on less exceptional grades.

FIFTH TRIAL.—The locomotives and wagons were taken across the railroad track to the other portion of the selected road—A, E, Fig. 5—where the grade was 4·27 feet rise in 100 of horizontal distance, or 225·46 feet per mile. This did not approach, in steepness, that already described, but it was, nevertheless, a heavy grade.

Engine No. 1 was here attached to a train of six loaded wagons, weighing, all together, 34080 pounds. Starting with 95 pounds of steam, it drew the train steadily, and with apparent ease, except when, as in the first trial, priming occasionally produced some annoyance.

SIXTH TRIAL.—The train was stopped, engine No. 2 was substituted for No. 1, and, with the same load, on the same grade, a trial of speed was made. The mean speed, over the whole course, was 3·6 miles per hour, that figure being somewhat exceeded at times.

The steam pressure varied between 90 and 105 pounds. The length of the course was 1435 feet.

Seventh and Last Trial.—A train of ten wagons was next made up, and engine No. 2 was attached. The total load was now 63400 *pounds;* the course was the same as during the preceding trial. Several unsuccessful attempts were made to start this load, the connecting chains snapping as soon as the strain came fully upon them. Chains were finally obtained of sufficient strength, and a start was made. The load, increased by the weight of a large number of men and boys who clustered upon the wagons, was taken to the top of the hill without accident and without a halt. The steam pressure varied between 85 and 124 pounds per square inch. At the lower pressure, the throttle was carried full open, and it was evident that all the steam that the engine would take was required to keep the piston moving. At starting, the engine exhibited a tendency to rise forward. It may be concluded from these two facts that this load was about a maximum for the engine when carrying 85 pounds of steam, and that, while drawing it, nearly all the weight of the engine was brought upon the drivers.

Even during this trial no slip of the driving-wheels could be detected, notwithstanding the fact, already stated, that they were smooth on their wearing surfaces. The marks left, by the bolt holes in their rims, upon the surface of the road were perfectly distinct and undistorted. The engine gave no trouble by priming.

It was noted, during the trials on this grade, that the wagons would just start backward down the hill when detached, and it is therefore to be concluded that the coëfficient of traction on a level, corresponding with the coëfficient of rolling resistance, must have been very nearly represented by the tangent of the angle of the grade, or about 0·0427; it may be assumed at 0·04.

Coal.—The amount of coal used on this engine during the day was 350 pounds.

Effect on the Road-bed.—During all trials, the effect produced by the locomotive upon the road surface was carefully observed and compared with that produced by the hoofs of the horses, which were at intervals climbing the second grade with loaded wagons similar to those used with the traction engine. The hoofs of the horses, it was noticed, cut into the road somewhat, loosening the metalling and injuring the surface, thus increasing the resistance offered to the vehicles following them. The wheels of the traction engine, on the con-

trary, very perceptibly compacted and improved the road, and thus, to some extent, reduced tractional resistances. There was a marked difference in the action of the two motors upon the surface, and it was evidently a matter of economical importance.

Horses vs. Steam.—Each wagon could usually be drawn to the top of the hill by two good horses, but only with very great effort. Three were required to do the work as comfortably as it should be done, and this number could pull a single load steadily and with moderate exertion.

The locomotive on this grade therefore performed the work of between twenty and thirty horses. We may conclude that it can, with 85 pounds of steam, draw a load which would require the severest exertion of twenty horses. The maximum steam pressure proposed by the builders of these engines is 130 pounds, at which pressure they are still far below the limit allowed by our own laws.

It was now late in the afternoon, and it was concluded to suspend work for lack of time to make up other trains.

The great steam road-roller was brought forward; its construction was examined by all present, and its effective action in compacting the road was observed. It moved backward and forward, on this grade of 225 feet to the mile, rapidly and steadily, and was said by its owner to be able to ascend the grade of 533 feet to the mile, upon which the first trial was made with the traction engine.

The day's work thus terminated and the party separated. The information which had been acquired respecting steam traction and the construction of metalled roads was most valuable, and it was considered by all that the day had been spent pleasantly and profitably.

Résumé.

Reviewing the experiments on the Aveling & Porter road locomotives and steam road-roller, we may make a brief *résumé* of the facts developed, thus:

1. A traction engine may be so constructed as to be capable of being easily and rapidly manœuvred on the common road and in the midst of any ordinary obstructions.

2. Such an engine may be placed in the hands of the average mechanic, or even of an intelligent youth of 16*, with confidence that he will quickly acquire, under instruction, the requisite knowledge and skill in its preservation and management.

* The manufacturers state that one of their most skillful drivers, at Wolverhampton, was a boy of 14.

3. An engine weighing rather more than five tons may be turned continuously in a circle of eighteen feet radius without difficulty and without slipping either driving wheel, even on rough ground, and may be turned in a roadway of a width but slightly greater than the length of the locomotive, by proper manœuvering.

4. A road locomotive, weighing 5 tons, 4 cwt., has been constructed, which is capable of drawing, on a good road, more than 23,000 pounds up the almost unexampled grade of 533 feet to the mile at the rate of four miles an hour.

5. Such a locomotive may be made, under similar conditions, to draw a load of more than 63,000 pounds up a hill rising 225 feet to the mile, at the rate of two miles per hour, doing the work of more than twenty horses.

6. The action of the traction engine upon the road is beneficial, even when exerting its maximum power, while, with horses, the injury to the road-bed is very noticeable.

7. The coëfficient of traction is, with such heavily laden and roughly made wagons as were used at South Orange, and under the circumstances noted, not far from *four per centum* on a well made macadamized road.

8. The amount of fuel, of good quality, used may be reckoned at less than 500 pounds per day, where the engine is a considerable portion of the time heavily loaded, and, during the remaining time, running light. It may be considered, without probability of serious error, that, during the trials at South Orange, Engine No. 2 performed pretty nearly an average day's work.

Deductions.—A number of interesting problems may be solved by reference to the facts learned here. A comparison of the efficiency of the road steam traction engine with that of horse-power, in drawing heavy loads, is especially important, and we will now make such a comparison, basing it upon the most reliable data at hand.

Traction Force.—It has been already stated that Engine No. 2 developed a tractive force equal to that of twenty horses.

The actual tractive force may be determined as follows:—The coëfficient of traction was, as has been shown, not far from 0·0427, which is also very nearly the maximum figure given by General Morin, as determined by his experiments with "dray-carts" and "*chariot-porte-corps d'artillerie,*" upon metalled roads and upon roads paved with sandstone.* This coëfficient is large, partly in conse-

* Morin's Mechanics: New York, D. Appleton & Co. 1860, p. 348.

quence of the very slight breadth of the wheel tires and the small diameter of the wheels of the wagons used, and partly because the wagon bodies were not mounted on springs. To be absolutely certain that no error is committed by over-estimation in the following calculation, this coëfficient will be taken at 0·03.

The actual tractive force required to overcome the rolling resistance was, then, $63{,}400 \times 0{\cdot}03 = 1902$ lbs. The force required to overcome that component of the force of gravity which directly resisted the motion of the load, in this case, where the road laid at an angle with the horizontal, whose tangent was 0·0427, was $W \sin \theta =$ 2,700 pounds; the total resistance was therefore 4,602 pounds.

Including the weight of the traction engine itself, these figures become 2,251 and 3·002 pounds, giving a total of 5,253 pounds direct resistance, and a coëfficient of adherence of $5{,}253 \div 18{,}348 = 0{\cdot}28$, which slightly exceeds that found on earlier trials of smooth wheels.

Experiments made by Capt. Robt. Merry, at the Jackson Iron Mine, Negaunee, Mich., and the observations and experiments of the writer, indicate the maximum direct tractive force of a good horse to be about 250 pounds. This corroborates the estimate already made, making *the tractive power of this engine equal to that of twenty horses.*

Deducing from the above the weight which could be drawn, on an equally excellent but level road, by this locomotive, the coëfficient of traction being the same, we find it equal to $\frac{5{,}253}{0{\cdot}03} = 175{,}100$ pounds, or very nearly eighty gross tons, and excluding the weight of the locomotive (163,452), seventy-five tons. With the machine, as with the animal, it would not be expected that, in regular work, on ordinary roads, more than one-half of the maximum power would be exacted,* although, with such a reserve, the machine possesses a decided advantage over the animal.

Working Time.—The working time of a horse is usually considered to be eight hours per day for dray horses, and less for carriage horses. The dray horse which is kept in harness eight hours per day, is usually standing unworked a considerable proportion of this time while his load is handled, and also during one-half, usually, of the remaining time, his vehicle is drawn unloaded. The horses of the Third Avenue street railroad, in New York City, are worked less than six hours per day, and are given one day in seven as a day of

* *Vide,* Steam Engines and Prime Movers: Rankine, chap. 3, p. 85.

rest. This is about equal to the working time of horses and cattle crossing our Western plains with moderate loads.

The steam engine requires no such careful limitation of working time. It can work twenty-four hours uninterruptedly as readily as a single hour. Ten hours a day would be, in most cases, made the daily working time of a road locomotive, the period being determined by the proper length of the working day of the driver, rather than by the capabilities of the machine.

The working time of the traction engine may therefore be stated to be, ordinarily, twenty per centum greater than that of the dray horse, and to be capable of indefinite extension when required.

The loss of working time by the horse through illness, at the farriery, &c., and that lost by the locomotive in the repair shop, are proper subjects for comparison, but it is difficult to determine them in the absence of reliable data. We may estimate these losses as equally affecting the two motors, with a probability that the correction of any error in such estimate may make a change favorable to the locomotive.

First Cost.—Comparing the first cost and running expenses of steam and of horse power, we may work from tolerably well established data. The list price of the Aveling & Porter road locomotive, experimented with at South Orange, is, delivered in New York, about $4,000.

The average cost of horses purchased by the Third Avenue Railroad in New York city, is now $157.50, and it would require more than twenty such horses to pull the load of the traction engine, while an addition of twenty-five per cent. must be made for the greater length of the working day of the locomotive. Twenty-five such horses would have a first cost of $3,937.50, to which must be added the large item of cost of harness.

The first cost of steam and of horse power is, therefore, nearly equal, the difference being in favor of steam, leaving, also, on the side of the engine, the immense advantage arising from its ability to work longer hours when required, and indefinitely. The interests on these first costs also nearly balance each other.

Running Expenses.—The running expenses of the locomotive consist of cost of attendance, of fuel, oil and repairs and of depreciation in value with use; those of horse power are attendance, food, stabling, sickness and depreciation with age.

The cost of attendance upon the one engine and the twenty-five horses may be taken at $939 and $3,130, respectively, assuming each

driver of the latter to be able to manage a six-horse team. The engine driver receives three dollars per day and the other men two dollars and a half, and there are are 313 working days in the year.

The cost of fuel, oil, and incidentals, excluding repairs of the engine and its depreciation, may be averaged at $900 per year, in the vicinity of New York. This is somewhat higher than the cost of similar items on railroad locomotives in New York State.*

The cost of repairs and depreciation has been thus far so small at South Orange that it could not be estimated, but for the life of the engine, it will be likely to average something less than fifteen per cent. of the first cost, or, in this case, $600 per annum. This we arrive at by an examination of railroad locomotive expenses,† as officially reported.

The total annual expense, therefore, of the traction engine referred to may be reckoned at $2,439 *as a maximum figure, including cost of attendance.* A similar estimate will give, for the annual expense of keeping one horse, very exactly $300, excluding attendance. In the year 1870, 10,315 horses in the State of New York cost for stabling, feeding, repairs to harness and shoes, &c., according to the official statements, $3,182,838.24, or $308.56 each animal. From this is to be deducted about eight dollars per head for receipts from sales of horses, leaving for annual expenses, say, $300 per horse. The expense account, excluding attendance, would be, for twenty-five horses, $7,500, as against $1,500 for a similar amount of steam power, *and, including attendance,* $10,500, as against $2,439.

Referring once more to the expense account of the Third Avenue Railroad, we find it working more economically than the average as given above. This company employs an immense number of horses, buys its supplies in large quantities, taking advantage of the market, and is able to do much better than could any individual or smaller capitalists. The following data were kindly furnished by Mr. Chas. S. Arthur:

Average first cost of horses, per head, . .	$157.50.
Average price obtained when sold, (3½ years later,	65.00.
Cost of stabling, general expenses and incidentals,	180.00.
Total annual expenses, including depreciation,	206.43.
Add to the above the cost of harness, (not stated), say, ...	3.00.

* State Engineer's Reports.

† This is about the figure on good railroads in the United States; on British roads the range is from 10 to 25 per cent. averaging very exactly 15 per cent.

The total annual cost of horse power, for comparison, 25 × \$209.43 = \$5,235.75, to which we add \$3,130 for drivers, and we make a total cost per year of \$8,365.75, to be compared with \$2,439, the total annual expense of the road locomotive capable of doing an equal amount of work.

The expense account when doing heavy work on the common road, under the described conditions, by steam power, is therefore less than 25 *per centum of the average cost of horse power*, as deduced from the total expense of such power in New York State, while *if we take for comparison the lowest estimate that we can find data for in our whole country, we still find the cost of steam power to be but* 29 *per centum of the expense of horses.*

We may state the fact in another way: *a steam traction engine, capable of doing the work of* 25 *horses, may be purchased and worked at as little expense as a team of six or eight horses.*

Prospective.—Thus, thirty years after the defeat of the intelligent, courageous and persistent Hancock and his co-workers in the scheme of applying the steam engine usefully on the common road, we find strong indications that, in a new form, the problem has been again attacked and at least partially solved. It was formerly supposed that success in the transportation of passengers by steam on post routes would lead to the application of that motor to the movement of heavy loads and to agricultural purposes generally. When, after so long a trial, the experiment finally seemed to have failed of success, it was believed that steam could not be applied to heavier work on common roads. As we have now seen, however, it appears probable that the inventors of that day attacked the problem at the wrong point, and that, on the common road, the transportation of heavy loads by steam being accomplished with economical success, under ordinarily favorable circumstances, it may prove introductory to the use of steam in carrying passengers and light freight at higher velocities.

Having examined in detail the capabilities of the road locomotive, and determined the value of steam traction on macadamized roads, and having obtained the measure of its economic superiority over horse-power, there remains to be considered the conditions which favor or retard its introduction, and to determine where it may be adopted without apprehension of failure.

One of the most important of the pre-requisites to ultimate success in the substitution of steam for animal power on the highway is that our roads shall be well made.

As the greatest care and judgment are exercised, and an immense outlay of capital is considered justifiable, in securing easy grades and a smooth track on our railroad routes, we may readily believe that similar precaution and outlay will be found advisable in adapting the common road to the road locomotive.

It is undeniably the fact that, even when relying upon horse-power, far less attention has been paid to the improvement of our roads than true economy would dictate. With steam-power, the gain by careful grading and excellence of construction of the road-bed become still more important. The animal mechanism is less affected in its power of drawing heavy loads than is the machine. With the horse, a bad road impedes transportation principally by resisting the movement of the load rather than of the animal, while with the traction engine the motor is as seriously retarded as the train which follows it, and frequently much more, on soft ground.

Steam, therefore, cannot be expected to attain its full measure of success on rough and ill-made roads; but where highways are as intelligently engineered and as thoroughly well-built as those on which the trials at South Orange were made, or where nature has relieved the engineer and the road-builder of the expensive work of grading, as throughout a very large extent of the western and southern portion of our country, we may expect to see the road locomotive rapidly introduced.

The earliest and most perfect success of the traction engine, and its probable successor, the steam-carriage, may be expected to occur in those districts. Its great economical advantage over animal power, as exhibited above, its freedom from liability to become disabled by epizoötic diseases, its reliability under all circumstances, and the many other advantages which are possessed by the machine, are already securing its rapid introduction, despite the difficulties arising from popular prejudice and unfamiliarity, from hostile municipal laws and other existing obstacles.

We are learning that this motor, when it can be used at all, is comparatively inexpensive; that our roads are improved by it, and that the ancient idea of its conflicting with the interests of owners and workers of horses is only a superstition.

We have found, by our experience with steam fire-engines, with the elevated railroad on Greenwich street, New York, and with railroads throughout the country, that the frightening of horses is but a temporary and a comparatively insignificant inconvenience. It would

seem to the engineer that the natural obstacles generally supposed to stand in the way have, after all, no real existence.

The principal inconvenience that may be anticipated will probably arise from the carelessness or avarice of proprietors which may sometimes cause them to appoint ignorant and inefficient engine-drivers, giving them charge of what are always excellent servants, but terrible masters. Nevertheless, as the transportation of passengers on railroads is found to be attended with less liability to loss of life or injury of person than their carriage by stage-coach, it will be found, very probably, that the general use of steam in transporting freight on common roads may be attended with less risk to life or property than to-day attends the use of horse-power.

This great economical revolution has now made a fair start, and is progressing with most encouraging rapidity. We may anticipate its complete success at no distant period. Meantime every member of the engineering profession may aid its progress by exerting a personal influence in favor of the improvement of our roads and the further improvement of the road locomotive, which has, as we have shown, at last assumed a practical shape, and has exhibited wonderful power. It is now at work in every portion of the civilized world, and the one establishment which constructed the engines above described is now furnishing employment to 1000 working men, supporting a total population, probably, of 5000 people.

Such a commencement having been made in a country like Great Britain, it is difficult to conceive how great may not be the future of this branch of industry when the valley of the Mississippi and our Western plains, the natural habitat of this motor, shall have become finally a principal seat of its manufacture as well as of its employment.

Stevens Institute of Technology, Hoboken, N. J., Oct., 1872.

A patent has recently been granted to H. J. Newton, of New York, for a plan of copper coating iron pipe—the design of the same being to secure a pipe or tube which should be capable of withstanding, for the greatest length of time, the very rapid oxidation which affects the tubular super-heaters for super-heating steam. After numerous experiments with steam super-heaters, the inventor affirms that he has found iron pipes coated with copper to serve the purpose better than any others, and he has secured a patent for the same as a new article of manufacture.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

A regular meeting of this Society was held at its rooms, in New York, on Wednesday evening, November 20th, 1872.

Mr. F. Collingwood read a paper on "Alcohol as an Illuminator in a Condensed Atmosphere," giving account of a comparative experiment, made in the west caisson of the New York bridge, with alcohol and candles, to test their illuminating power under a pressure of 31 lbs., and at a temperature of 80° F.

The lamp had a loose cotton wick, $\frac{1}{4}''$ in diameter; the base of the flame was 2'' above the surface of the alcohol. The candle, of stearine, was $1\frac{1}{4}''$ in diameter.

There was consumed per hour, under pressure, 6 cubic inches of alcohol and $\frac{5}{8}$ ounce of stearine, and in the open air 2 cubic inches of alcohol and $\frac{4}{9}$ ounce of stearine.

In the condensed atmosphere the lamp burned with a clear, bright flame, not blue, without smoke, and gave three-fourths as much light as the candle, which smoked greatly.

Taking into account the waste of stearine by flaring and short pieces not burnt, with alcohol at $2 per gallon and candles at 28 cts. per pound, for an equal amount of light that from alcohol costs about twice as much as that from stearine.

It is suggested that a mixture might be made of alcohol and some carbonizing fluid to burn without smoking in a condensed atmosphere, the proportions to be varied to correspond with the change of pressure.

A paper, by Mr. T. Guilford Smith, on "Coal-Cutting Machinery in England under the Present Prices of Coal," was read, which presented the observations of the writer during the late great rise in prices of coal there.

The efforts made in England to cut coal by machinery had not met with much encouragement until a comparatively recent date, when the demand for coal increasing beyond precedent gave the miners a chance to strike for higher wages.

For some time there has been an increasing and alarming difficulty in obtaining a supply of coal at the great trade centres, caused by disputes about working hours, the colliers' strikes, the demand in new iron districts and in foreign countries.

In July last, London prices of coal were from 24 to 32 shillings per ton. Commenting upon this, the "London Evening Standard"

said: "A suggestion has been made, of which we heartily approve, that the importation to foreign ports might be to a certain extent checked by a reasonable export duty on the material which has been called the third necessity of life,—the order running—bread, meat, coal. We may rely upon it that whatever impost we lay, the Russians will still be our customers; but, in addition to them and the Germans. the French, the Spaniards, the Austrians, the Italians, the Egyptians, and even the Americans come to our markets. The French and the Italian governments coal their steam navies from our mines, so do most of the great trading companies of the Continent and the principal packet lines. It is we who set going the locomotives of the Indian, of the Swedish, of the Danube and Black Sea, of the North Russian and of the Egyptian railways."

To determine the merits of the various coal-cutting machines naturally resorted to in this emergency as a saving of hand labor, a competitive trial has been proposed, to take place at an early day.

Probably no machine will in all cases be the best, and doubtless many changes will be requisite to adapt an English machine for use in American mines.

The cost of coal-cutting in England varies from one-half to one-third the total cost of mining.

Several machines were described at length. One, costing £160, driven in pairs by air compressors costing £500, is said to do the work of 40 men in a 2½ or 3 foot seam: it is 6 feet long and 2½ feet wide, and carries at one end a horizontal arm, around which passes an endless chain, provided with strong steel cutters; these cut at the rate of 45 feet per hour.

Another machine, operated by hydraulic pressure, will, by means of a series of reciprocating cutters, arranged upon a horizontal arm, cut 15 yards per hour 4 feet into or under the coal, at any height or angle. It is claimed that with this machine a seam will yield 1000 more tons of coal per acre than when worked in the usual manner.

A third machine, costing £150 and also driven by compressed air, has cutters arranged like saw teeth around a horizontal wheel 3½ feet in diameter, which cuts into the seam 3 feet in depth. Its regular night's work was a groove 120 yards long, 3 inches wide, and 34 inches deep—the proportion of slack to coal being but one to ten.

Other machines, similar in character, were mentioned; also a rock drill, invented by Gen. Haupt, of Pennsylvania, which, after 22 modifications, is now capable of drilling a 2-inch hole in granite 6½ inches per minute.

Should the prices of coal quoted continue for any time, our American fields may have a chance to ship their products into new channels—Nova Scotia having already taken the lead. In October, orders transferred from Liverpool, England, were received in Georgetown, D. C., for large quantities of Cumberland coal, to be shipped to Bombay, Aden, Egypt, Rio Janeiro, and various foreign ports.

Mr. J. Dutton Steele remarked, through the Secretary:—Coal cutting machinery has not thus far been introduced into this country. The operation of cutting coal is chiefly confined to cutting a deep groove or channel in or under the veins so that the miners may pry down the coal that is above it. Generally but one such groove in a vein is required; the cost of cutting per ton of coal will therefore be inversely as the thickness of the veins. The English veins referred to are 2 ft. 10 inches and 2 ft. 4 inches thick. Workable American bituminous veins are from 4 to 8 feet thick, and our anthracite veins from twenty to even fifty feet, which will account, to some extent, for our indifference relative to coal-cutting machines.

There is another reason; powder is freely used by our miners. It is less work to blast out the bottom of the veins than to cut under them, but more wasteful; if powder represents the minimum of labor, cutting under represents the minimum of waste. Nor is waste the only objection to the use of powder; it vitiates the air and occasionally sets fire to the mines.

With cutting machinery, compressed air as a motor will be introduced into the mines, whereby the ventilation will be improved, and the liability to fire reduced. In the anthracite regions, pumping and hoisting engines, with their steam boilers, are put under ground, and shafts cut out hundreds of feet above them for the escape of smoke and steam. Inextinguishable fires in the mines are the direct result of this practice. Steam should be made upon the surface, and there used to compress air to drive the engines below.

I think machines working by impact are preferable to those having rotary cutters. One weighing six hundred pounds, and supplied with a circular inch of air at fifty pounds pressure per square inch, will strike three hundred blows per minute, each with a force of three hundred pounds; and with suitable cutters it should cut under rapidly. By changing the cutters, the machine could drill ranges of holes, which would aid in breaking down the coal. Thereby the waste, liability to fire and the cost of mining would be largely reduced, and the mining interests be more independent of labor.

Mr. Miles Coryell remarked:—Without doubt, coal-cutting machinery, when further developed and perfected, will be useful in mining bituminous coal. It, however, does not seem applicable to the hard anthracite veins of this country.

It is hoped that the use of steam or compressed air, wherever it can take the place of manual labor, will aid in subduing the lawless spirit among the miners, who now work and control our mines.

Mine owners generally are not sufficiently interested in improvements, and do not appreciate the need of a cheaper, safer and less wasteful system, which, with wise encouragement and moderate pecuniary aid, would surely be developed.

In anthracite mines, the seams are irregular and the coal of variable hardness, sometimes interspersed with sulphurets, which resist almost any cutting tool. The diamond drill has been profitably used for drilling long holes between "breasts." With it openings can be made through which noxious gases will escape; it is also of service in determining the position and depth of veins.

More attention should be paid to improving the means of transportation in the mines. A locomotive, with large steam capacity, might be economically employed to draw the cars by day, and to drill holes for mining by night.

The Secretary exhibited models and drawings of machines for boring and drilling rock, and specimens of work done, explained the methods, and stated the cost of operating each.

Prof. De Volson Wood generally reviewed the history of rock drilling by power. He also noticed the difficulties surmounted and yet to be overcome, and the results already secured.

A discussion followed, participated in by most of the members present. The subject of coal-cutting and rock-drilling by power will be taken up again at a future meeting. Members and others are asked to communicate, meanwhile, to the Secretary, for presentation then to the Society, whatever professional experience they may have in the matter.

Carbon Prints on Plaster and Clay.—It is feasible, according to Richard Jacobsen, to secure carbon prints upon wares of this kind. It is stated to possess excellent features, which will secure for it extended application in the future. For burning in such prints, the carbon paper should be coated with gelatin and some fusible pigment instead of gelatin and India ink.

THE ELDRIDGE BOILER CIRCULATION.

No fact is more clearly established than that circulation of water in a vessel in which it is heated is vitally essential to the process of heating. Metals conduct heat from one portion to another through the contact of the particles, but water can only take up the heat by the particle which is directly in contact with the heating surface, which, being thus made lighter, rises and so conveys the heat through the mass, giving place for a fresh particle, which is in its turn heated and moved away.

This condition of things has been recognized ever since the steam-boiler became part of a working machine, as a consequence of the invention and improvement of the engine—and the desideratum with inventors has constantly been to produce that circulation; the importance of which has been fully and universally recognized among intelligent engineers from the earliest period. The estimation in which it is held at present is exemplified in the report of Robert B. Longridge, Chief Engineer of the Manchester (England) Boiler Insurance Company, upon the Relative Economy and Durability of Stationary Boilers, presented in September, 1859, which is quoted and approved in the report of the Committee of the Franklin Institute (of Pennsylvania) upon the Mode of Determining the Horse-Power of Steam-Boilers, presented in June, 1872. (See "Journal of the Franklin Institute," August, 1872, p. 91).

Heretofore the efforts towards the production of this circulation have been almost entirely confined to one class of expedients—that of pipes—necessarily of small dimensions—in which the water, being heated, rises, drawing fresh water after it, and so, gradually, the whole body of the water in the boiler is passed over the heating surface of the circulating pipes, having, however, no proper circulation except within them; such apparatus being always liable to derangement from the loosening of the joints by the different heats and consequent different expansions of the body of the boiler and the different pipes.

This pipe system will be recognized as the basis of the hundred different varieties of "circulating" boilers, and, slow and imperfect as it is, produces results far superior to those attained where there is no circulation at all.

If, however, the whole body of the water in the boiler shall be put into an active and positive circulation over the whole fire surface, con-

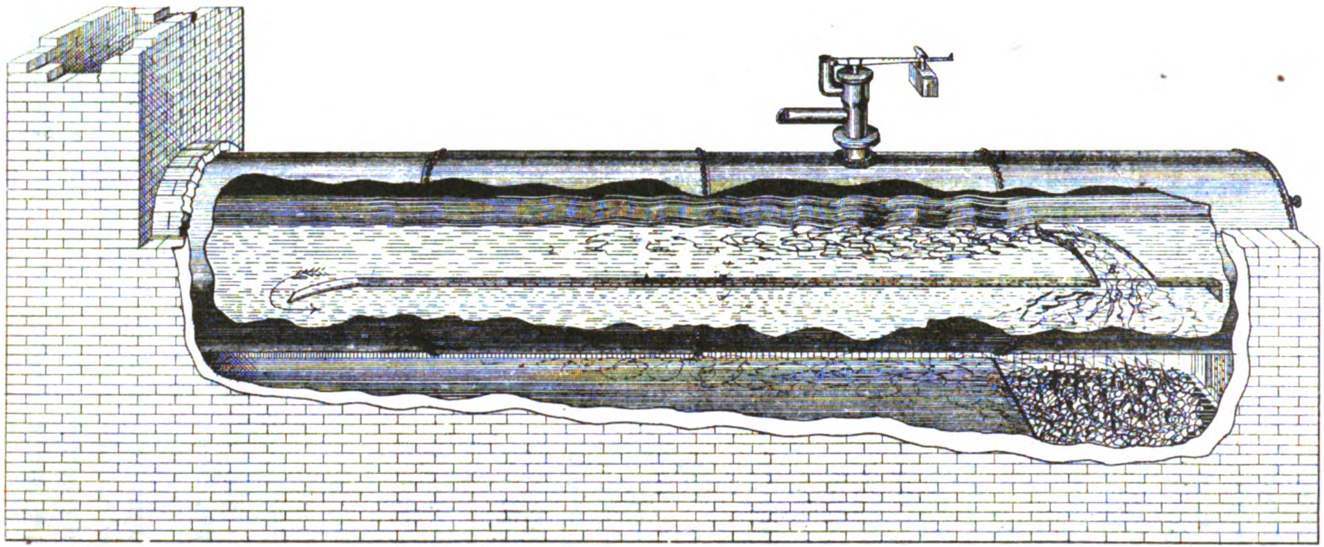
stantly passing from the coolest to the hottest part, all the advantages gained by the pipe circulation will be secured with manifold increase, and other desirable results will be attained, while the evils of over-heated plates and scaled surfaces will be entirely and certainly obviated.

A boiler in which is such a current cannot prime; the swift return current on the surface to supply that on the bottom will force the water to lie flat, no matter how rapid the production of steam or how foul the water. A swift current, as in a mill-race or a mountain torrent, is flat—the foam only comes when the current is obstructed and entangled.

All this is effectually done by the apparatus illustrated in the annexed drawing, which operates simply by taking advantage of the well-known fact, that a gas rising through a funnel-shaped opening in a liquid will carry up with it a current of the liquid whose rapidity is in direct proportion to the supply, and the speed of the gas.

As will be evident from an inspection of the drawing, which represents a plain cylinder boiler broken away to show the circulating apparatus which is represented in section within it, the most of the steam is generated under the diaphragm or shelf, A, which extends from a point close to the head to within a short distance from the rear of the boiler.

This diaphragm is arched from side to side, is depressed near the rear end, and is provided with an apron at its head, so that all the steam so generated under it must pass out through the funnel, B (which is placed over the point of greatest heat), and cannot otherwise escape; and in its passage through the funnel, the steam sweeps with it a rapid current of water, which is impelled toward the rear of the boiler—the funnel being inclined in that direction, and this current from the funnel carries with it the whole of the water which is above the diaphragm toward the rear of the boiler, where it passes under the diaphragm and over the whole fire surface to the hottest part, again to be discharged through the funnel, and to repeat the circuit. The space between the head of the boiler and the head of the diaphragm allows a passage to the rapid current so formed (which is greater than could find vent through the funnel), increasing the circulation and avoiding any space whatever of dead water in the boiler. Thus, fresh water being constantly and regularly presented to the heating surface, and the steam swept away as fast as formed, without interference with the current, it is clear that the heat will be taken



The Eldridge Boiler Circulation.

S. Williams Del.

Photo-lith. by A. DICKES.

125 S. 4th St. Phila.

from the iron as fast as received, and at the same time the greatest amount of evaporation produced from the fuel consumed, and the iron effectually protected from overheating and from scale.

It is too evident to need an illustration that the same apparatus, with slight modifications of form, is as well applicable to flue and to multitubular boilers, with equal advantage as to prevention of priming and scale, and producing equal increase of evaporative power, and avoidance of destruction by overheating upon the crown sheet and shell.

By guides, easily introduced, the current may be caused to sweep those parts of a tubular boiler in which mud accumulates injuriously, and thus the whole kept clean and in effective working order.

For this apparatus—simple, cheap, effective, and readily applicable to any boiler now in use, without disturbing or deranging it—letters-patent have been granted to me, and I present it to the consideration of all men interested in steam-power, in the economy of fuel, and in the vitality of boilers.

For further information, address G. Morgan Eldridge, 708 Walnut street, Philadelphia, Pa.

WHITWELL'S FIRE-BRICK STOVE FOR SUPERHEATING BLAST IN IRON SMELTING.

During the last forty years Neilson, of Glasgow, proposed to heat the air blown into the blast furnace. The success of his novel idea revolutionized the iron trade. Hot blast was accepted as a necessity, and subsequent improvers have confined their attention to such modified forms of apparatus as would give greater efficiency in actual working.

Pipe stoves were once universal, as were stage-coaches before the introduction of railroads, the chief difference being that in the one case the inconvenience and delay of stage-travelling were confined to outlying districts and the memory of middle-aged men, whilst the inconveniences and delays of pipe-stoves have caused anxiety and loss to most of the present furnace owners all over the world. Siemens cut the Gordian knot of economical heats, and Cowper applied to hot blast the regenerative principle that Siemens had patented, and obtained heats and economy of fuel that previously had been quite unknown, coupled with enlarged production. Cowper's stove has not had the

measure of success that its principle undoubtedly entitles it to, as engineering imperfections and mechanical faultiness in construction have been much against it. Whitwell's stove is an improvement on the Siemens-Cowper stove, and is remarkable for its power, its longevity, its simplicity of construction, and, above all, its never getting out of order, or—rather to tabulate the distinguishing advantages of these stoves—

1st. That they will stand a temperature of 2000 degrees without damage.

2d. There is *no* wear and tear of cast-iron pipes or material.

3d. These stoves are sooner cleaned than any others, the time required between laying off and starting again being 6 hours; they are not cooled down, but are cleaned from the outside while red-hot; this occurs about every two months.

4th. The principle on which the stoves are constructed insures the greatest economy of gas or fuel, whilst the heat that is obtained in the blast is nearly the whole of that given off by such gas or fuel.

5th. The cost of the stoves is not proportionately more per furnace than that of ordinary cast-iron plant, equal to modern requirements.

6th. These fire-brick stoves effect a saving of several cwts. of fuel, per ton of iron made, and largely stimulate the production.

7th. The stoves being rivetted and caulked air-tight, there is no loss by bad joints, and hence a large amount of wear and tear is saved to the blowing-engines.

8th. The areas throughout are so regulated that there is *no loss* of pressure by friction, but a pressure of 4 lbs. in the engine-house gives *an equal pressure at the tuyere* where the plans of the patentee are properly carried out.

9th. The immense reservoir of caloric stored up in these stoves (each red-hot wall acting as a fly-wheel, so to speak, and giving out its power when most required) produces the best effect on the working of a furnace, preventing its running off into inferior qualities of iron.

10th. These stoves form *a perfect regulator* to the blast, acting in this respect as the air-vessel in a force-pump, and dispensing altogether with the large air-regulators that are found necessary in many works, the blast being perfectly steady at the tuyere.

These stoves have been used for seven years by the firm of William Whitwell & Co., South Stockton-on-Tees, England. Two years since, the Consett Iron Co., Durham, erected their fourth set of four, and

Fig. 1 — Vertical section

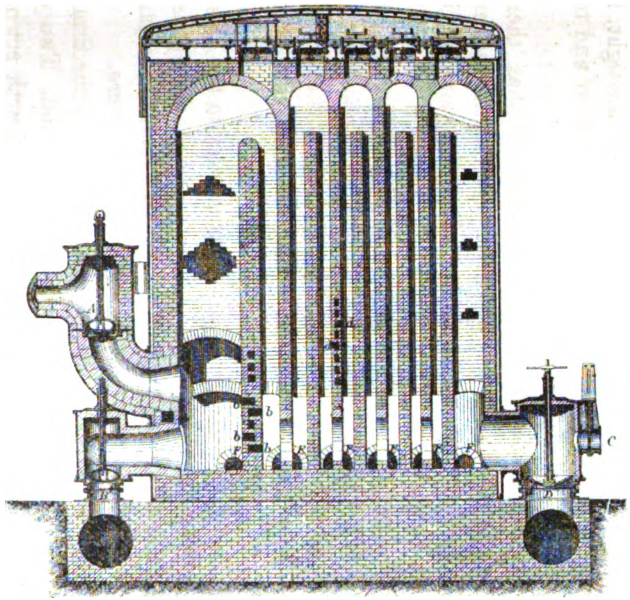
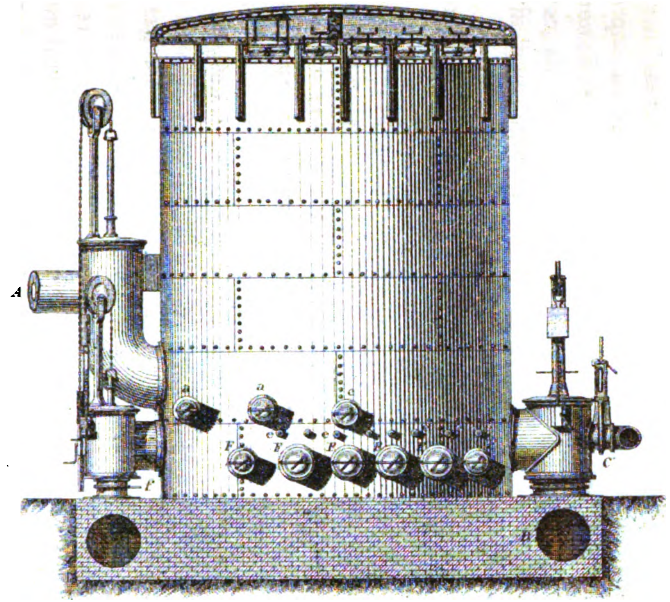


Fig. 2 — Elevation



WHITWELL'S HOT BLAST FIRE BRICK STOVES

Photo-lith: by A. DICKES 125 S. 4th St. Phila:

are now building the fifth set, making twenty in all. Up to September last the number in blast was 44, and those in construction (they take three months to construct and erect) were 86. An enterprising firm on Lake Champlain, N. Y., are introducing them, for use with anthracite, to which fuel they are well suited. They are equally suited to any class of ore, and work equally well with coke, charcoal or coal. A drawing is annexed of these stoves, which we may thus explain, viz.:

FIG. 1. HEATING THE STOVE.—*Vertical Section.*—The hot blast valve, A, and the cold blast valve, C, being closed, the gas valve, B, is opened, through which the gas enters the stove, and traverses up and down the spaces between the upright walls, and enters the chimney flue by the valve D. Heated air is supplied to the gas by means of the air valves, *a* and *c*, and passages, *b* and *d*, by which a most intense combustion is gained. The internal heat of the stove as well as the combustion of the gas is observed by the eye-pieces, *e e*.

FIG. 1, 2. HEATING THE BLAST.—The chimney valve, D, and gas valve, B, being closed, and the hot blast valve, A, being opened, the cold blast is admitted through the cold blast valve, C, and issues from the stove by the valve A, *red-hot;* all other valves being closed perfectly tight.

FIG. 1, 3, 4. CLEANING THE STOVE.—When it is required to clean a stove, the top cleaning-doors, E, are opened and the walls scraped with the "cleaning-tools," when the dust deposited on the heating surfaces falls to the bottom of the stove, and is removed by the bottom cleaning-doors, F.

The lower plan shows the arrangement of the stoves to four furnaces *in full blast* at the Consett Iron Works; but this plan may be varied to suit all circumstances.

Outside of England, France, Prussia, Alsace and Lorraine, Luxembourg, Westphalia and Spain have adopted them with perfect satisfaction. Patents have been granted for this invention in Great Britain, France, Belgium, the United States, Luxembourg, Russia, Austria, Spain, Portugal, Sweden, Norway, Italy, the East Indies and New Zealand.

Chemistry, Physics, Technology, etc.

PREMATURE DECAY OF TIMBER.

(Suggested by an Examination of the Wreck of the late Steam Frigate Chattanooga.)

By Hector Orr, Member of the Institute.

Read before the Institute, Nov. 22, 1872.

We are generally aware of the building and equipment of the frigate Chattanooga at this port about the close of the late war. We also know that this vessel was injured by the ice and partially sank off League Island last winter. During the summer just passed she was sold as a wreck and bought by Mr. Alexander Purves, long known in the iron trade of this city, and who is an active member of the Institute and also of its Meteorological Section. At a meeting of this Section I inquired of Mr. P. concerning this wreck, and to his politeness I am indebted for the opportunity of examining the same and presenting these few thoughts thereon to the Institute.

I found this vessel (or at least her hull) lying on the flats above Gloucester City on the New Jersey shore. Her length over all was 350 feet, with a keel alone of 300 ft. Her outfit embraced a three-blade propellor 18 feet in diameter, of tough compound metal, and a powerful steam engine of Merrick's best workmanship.

All the machinery had been removed and the work of demolition had begun both fore and aft from the bulwarks downward; but the great mass of her bulk was there. The amount of "dead wood" presented at the bow and stern was enormous. The stern, as the seat of the propeller, required an extra mass, and the bow seemed intended to act the part of a naval "Ram." The "ribs" or timbers were but a few inches apart and had chock-braces at every few feet, and amidships, diagonal wrought iron straps were placed in abundance across the timbers.

All the just constituents of a noble ship seemed to be there, and each in its right place; but in all this structure there was scarcely a sound piece of wood six feet long! White pine, yellow pine or oak—ribs, planking, lining or deck—all were smitten as with a common plague, presenting a mass of rottenness which crumbled at your tread, nay, even at your touch!

Less than eight years ago the keel of this ship was laid. She

scarcely left the waters of the Delaware, never threw a broadside or saw an enemy. The Rebellion waned as she grew into shape, and expired almost at the first movement of her engine. Thus far she had a happy history—that of her remaining life is far different.

Mr. Purves has dealt with other wrecks of various dates of life and service, and in his company I met experienced seamen and ship carpenters, and they all unite in saying that they never saw the like of this! Numerous specimens of this wreck will be found on our table, marked as to position and kind of wood, taken from the kelson upwards. Near the forward bends the timbers were *doubled*. I noted one or more instances in which a pine log and an oak log were thus coupled, and the decay had evidently began at the inner surfaces, which were in direct contact with each other; but even where both logs were of the same wood the same inward decay appeared. Whether in the undisturbed mass, or where pierced with iron or copper fastenings, or even with the humble tree-nail, the fibre was completely broken up.

My friend Dr. Reynell Coates has reminded me that the fleet of Commodore Perry, which was built in haste from timber cut on the lake shore for service in the War of 1812, suffered from early rot, so that the vessels were pronounced unseaworthy soon after the peace of 1815.

Also, Mr. Purves assures me that he has known a strange tendency to decay in some vessels, indicating a sort of triennial crisis in their early life, which, if passed without injury to the wood, predicted some twenty-five years of wear. It is somewhat analogous to the test of the third summer in children. I do not insist on the analogy, but we may recollect that out of such unpretentious facts as we are here recording, Newton and Franklin started their wonderful discoveries.

I have learned from Mr. Durfee (Supt. of the Midvale Steel Works) that he has witnessed a few marked instances of decay in large pieces of timber, such as pillars, girders and even rafters, that were *cased* in light boards to improve the appearance of the room; the inner mass being found dangerously rotten. And here I will take the liberty to say that I have for full forty years watched the not very graceful deflection of our girders in the ceiling above us, and I think that it may be worth while to test their internal solidity at some convenient season not far distant. If we let this hint come "home to our business" now, it may prevent its coming "home to our bosoms" unpleasantly eventually.

Mr. Purves has farther noted the decay of wood on shipboard under circumstances which seem to me quite worthy of attention: On por-

tions of the "lining" of vessels covered with zinc or tin, as in provision closets, &c., the decay followed exactly the surface covered by the metal, indicating the action of "dead air" in contrast with that of a free atmosphere on the surrounding parts which remained sound.

The observations of both the gentlemen last quoted point to a state of things very similar existing between the timbers of the Chattanooga, enclosed by planking outside and by the lining or ceiling inside—chambers for dead air were thus formed throughout the entire hull; and the other testimony kindly offered me by others, I hope may tend to give us the clue to avoid in future the sad result which furnishes the title to these remarks.

I have already alluded to the short duration of our war navy on the Lakes. Its vessels were built in haste for a pressing emergency. The same is true of the Chattanooga; but nearly sixty years have passed since Perry's victory, and what years of progress have they been! In them have arisen the ocean steamship, the locomotive, and the railway, the telegraph, and the FRANKLIN INSTITUTE. We have had various processes brought out in this period for the preservation and speedy seasoning of wood. I could not name them all, much less describe them; I will mention one, however, which seemed to me worthy of attention from its simplicity and apparent effectiveness. It is perhaps fifteen years since my friend, Mordecai R. Moore, late member of our City Council, made known to me what he considered a valuable improvement in the seasoning of timber. I am not sure that the invention was patented. It was not invented by Mr. Moore, but he was persuaded of its value. The process consisted in charging the freshly-cut wood with super-heated steam, for a period of twenty-four hours; then by powerful apparatus exhausting all fluid from the fibre, and charging it anew with dry and highly-heated air for another twenty-four hours; and on the third day the wood was ready for use.

Like too many of the group, which seems but a few at best, Mr. Moore is dead; and thus far I have not been able to trace up this invention in present hands. Even if it was patented, its date must be out by this time; but the process certainly ought not to be forgotten. If this marvellous decay which I am relating to you, is due to the haste with which the work had to be done, surely this two days' process would not have delayed it much; and look at the consequences! In the condition in which Mr. Purves took possession of this vessel, she had hardly the strength of a partition of lath. She sank before the ice last winter, because her empty bulk was too much for her

strength even in the placid waters of the Delaware. In her first storm at sea she would have been but a ready-made coffin of unusual shape to all on board.

There is still another consideration which I will present here, as to the hygienic condition of such a structure. Some seventeen years ago, our venerable and excellent citizen, Dr. René La Roche, set himself to write the history of the *Yellow Fever*. It is in two thick volumes 8vo, and I read the "proof" of its pages. It embraces piles of conflicting testimony, but at least one definite conclusion was attained, to this effect—that in all well ascertained centres of production and diffusion of said disease, three conditions were always present, namely, *heat*, *moisture* and *decayed wood*. Now, mark this; I am quoting from a work at least seventeen years old, yet follow me aboard this unfortunate vessel for a few minutes, and see how it applies there. As to moisture, her mere bilge water would furnish this, even without the drippings from tanks and boilers; the heat is insured by her furnaces, which a cruise in the tropics would aggravate, and surely the *rotten wood* was there at once in profusion and perfection. Ponder the fate of this ship's company; danger without and covert, lurking death within—around poor Jack's humble hammock and in his very nostrils.

And to show you that I am not drawing upon fiction, our observant Actuary informed me, a few days ago, that one of our physicians had actually detected a well marked disease on board this very vessel.

Mr. President, I have no special personal interest in this case of our abandoned frigate, and surely take no pleasure in this recital. But we participated in the fame of the noble ships which for a hundred years have been built here, and we must share in the shame of this one.

I will close with the hope that we may never see such another war as the one we have happily closed, nor such another war-ship as the one I have just examined!

DISCUSSION.

Mr. Close arose to correct a portion of the statement in Mr. Orr's paper as to the Chattanooga never having left the waters of the Delaware river. Mr. C. went on to state that the contract required the ship to have a trial at sea, the wheels to be turned a certain number of times, and consume a certain quantity of coal in a given time, and under the supervision of Mr. Zeller, the chief engineer, the test was accomplished, the ship being at sea three days.

And as to the decay of the wood, Mr. C. went on to state that at the time the ship was building no yellow pine timber of good quality could be obtained, (during the Rebellion), and a substitute had to be made of the Bastard or Norway pine, then growing in Northwestern Pennsylvania, which has little or no traces of the resinous material as found in the yellow pine grown in the Southern States; in fact, an expert will tell within fifty miles of the latitude where a certain picee of yellow pine grew, if shown to him. The decay commenced in the sap of the Norway pine, caused by want of ventilation, which disease was communicated to the oak frame by contact and want of ventilation. Woods that have been preserved under water on the Kensington side of the Delaware river have been laid on the ground at Petty's Island and rotted to spunk or earth in one year, while the same wood laid on the ground on Kensington side showed no signs of decay after remaining several years exposed.

Mr. C., on being questioned as to the time of year of the cutting of the timber having something to do with the decay, he stated that that theory was approved by workers of timber, but he had very little faith in it.

Mr. Orr gave pointed attention to the remarks of Mr. Close, and then rejoined that he certainly had understood from Mr. Purves that the vessel had never gone to sea. He was rather incredulous still as to the actual length of her longest voyage. All the other explanations of Mr. C. confirmed Mr. Orr's specifications. He inquired of Mr. Close if he was acquainted with the "seasoning" process of Mr. Moore, which had been described, and on Mr. C. disclaiming any knowledge of the same, Mr. O. ended his response by saying he was glad to learn that the Chattanooga had gone far enough to get her worthy contractors their pay, which he believed was the only good thing done by said vessel.

Mr. Durfee said his knowledge bearing on the immediate subject under discussion related mainly to the case of a church of quite recent erection, whose rafters or roof timbers had been enclosed in attractive casings to give finish to the interior, and upon occasion arising for the application of nails to said ceiling, at the single stroke of the hammer the nail penetrated to its head, the inner wood being quite destroyed.

Mr. Close recollected a very similar case in a roof where the enclosed wood was reduced to comparative powder.

The Treasurer of the Institute, Mr. Frederick Fraley, (who had

already reported a series of obituary resolutions on the death of Prof. Frazer, and given an extended extempore address on the lamented Mr. Agnew), rose and apologised for again taking the floor, but urged the importance of the subject as his excuse. After alluding, parenthetically, to the severe loss by fires within the past twelve months, especially in Chicago and Boston, and inviting the attention of the Institute to the devising of additional means for meeting and preventing such calamity—went on to state his experience in ship-building in the unpretentious item of canal boats, in whose structure his Company had been induced to dispense with the inner covering (or ceiling), and by a strong outer planking carefully joined and calked, the inner surface of the ribs was left bare, with a decidedly improved result on the endurance of the wood, proving the valuable effect of free circulation of air and the action of light also in such instances.

The President (Mr. C. Sellers) also offered further testimony condemnatory of the practice of insulating wood from the action of light and free air. In his own house (of comparatively late construction), he accidentally detected a serious defection in his principal floor—the ends of its joists being almost uniformly rotted off even with the wall in which they had been inserted; while in a very old family building (viz., that of his grandfather), the joists were found to be uninjured; but said joists presented their ends to the air, which had free access to their surface.

Mr. Orr rose, by permission, to call attention to the remarkably uniform tendency of the testimony volunteered as to the evil of enclosed timbers, and he was afraid that it leaned too much in one direction. He appealed to Mr. Fraley's recollection of Cope's first line of packet ships, built by good Robert Burton on an average of 50 years ago. Those ships ran regularly for 25 years on said line and then were sold as whalers, and were perhaps still afloat. The present Tuscarora (the second of the name) was still a model of strength and beauty, though once struck by an iceberg full 20 years ago, and again having the misfortune to lay aground near Cape Henlopen through a part of a winter. Yet all these ships were built with *enclosed timbers*, planked and ceiled, on the very plan which we now seemed ready to condemn! He wished the subject to be looked at, not only on both sides but all around. He had met some bluff specimens of *artists* on board the wreck, who vowed their belief that "wood *growed* different now from that cut long ago." He had thought much on this terrible decay of wood, both in ships and bridges and in street pavement, and hoped members would take the consideration of the matter home with them.

Mr. Fraley fully endorsed Mr. Orr's description of those noble ships of other days, and admitted their strange contradiction of our present experience in this department of mechanics. He wished to call attention to one more fact on the general subject—that at the dates to which Mr. Orr, referred it was the practice of Philadelphia shipbuilders to apply coarse salt between the timbers of the best ships.

The Session having now been extended beyond the usual time, the discussion was arrested for the present by a motion to adjourn.

BITUMINOUS COAL; ITS ORIGIN, VARIETIES AND A FEW OF ITS SPECIAL USES.

The substance of a paper presented at the Dubuque Meeting of the American Association for the Advancement of Science.

By E. B. Andrews, of the Ohio Geological Survey.

Notwithstanding the elaborate attempt of Bischoff and others to prove that coal is an accumulation of vegetable detritus, drifted by rivers and buried beneath accumulating sediments in the ocean, this view is not now accepted by any who have carefully studied the coal seams in the Coal Measures in America. Lesquereux and Dawson have shown, as the results of careful and extended observations, that the vegetation forming seams of coal grew where it is now buried, the only movement being downward, in the general subsidence. By this subsidence, sedimentary materials were brought in over the vegetable mass, filling up the water so as to form, in time, a new subaërial surface, on which new vegetation took root and grew, to form in turn, when buried, another seam of coal. My own independent observations, continued through many years, convince me that in no other way were the seams of coal in our true Coal Measures formed. There is, moreover, every evidence that the vegetation grew upon marshy plains, more or less extensive, skirting the ocean, or, perhaps, often constituting low islands not far from an ancient shore. This appears from the fact that the slates and shales accompanying the coal and in immediate proximity to it, often contain marine or brackish-water forms of late palæozoic life. These slates sometimes constitute partings in the coal seam itself, and extend for miles, maintaining with wonderful exactness their stratigraphical position. These partings imply a temporary overflow of the ancient marsh by the ocean, and an even distribution of sediment, which when compressed constitutes the thin layer of shale or clay. Besides, we find in the very coal

itself, and especially in the cannel portions of seams,—for cannel coal is, so far as my observations go, only a local modification of a regular bituminous coal-seam,—marine forms of ancient life, of which *Lingulæ* and fishes are, perhaps, most common.

We also find in some seams of coal the evidences of tidal or other overflow of the coal-marsh, in beach-worn sticks and various forms of wood which, now changed to bisulphide of iron, are preserved in their original form, and lie in the coal as they were drifted into the old marsh. After the complete subsidence of the whole marsh, we often find the proofs that such trees as *Sigillaria*, *Lepidodendra* and taller ferns were broken down where they grew, by the incoming waters, and buried on the spot by the sediments. I once traced the trunk of a *Sigillaria* in the roof of the Pomeroy, Ohio, seam of coal, for a distance of more than forty feet. Thousands of the trunks of what Lesquereux takes to be *Pecopteris arborescens* are found in the slates over the same coal, lying in horizontal burial as they were bent or broken down by the waters which also brought in their stony winding-sheet. In making almost thousands of geological sections in our Coal Measures, I have found seams of coal always maintaining such relations to what were the ancient water levels, that I am fully convinced that in every case the vegetation grew along the water-line and not far above it.

I have never found the slightest proof of the formation of a seam of coal over hills or high grounds. The parallelism of the seams, of which further mention will be made, forbids it. Doubtless, vegetation of certain kinds grew on the higher grounds, but this vegetation did not constitute seams of coal. It is plain that whatever vegetable matter there might be on a hillside would in the subsidence of the land present to the waves of the encroaching sea an easy prey, and the trees and humbler plants would be torn from their exposed moorings, and be drifted away to rot upon the waters or be buried in the sands of the beach.

Such drifted and buried trees are frequently found. Should there have been some high level plateau, on which vegetation grew, and which in the subsidence was let down below the water so evenly as t prevent the waters from tearing the vegetable materials away, it is still doubtful whether, on such high and dry areas, there would have been any considerable accumulation of vegetable matter, the decay so equalling the growth, that in reality there would have been no materials for a true seam of coal.

While the vegetation forming the coal seams grew upon marshy savannahs skirting the ocean, we find constant proof that the continuity of the marsh was often broken by intervening water, so that the seam of coal is frequently interrupted. In the subsequent subsidence these water spaces were filled up with sands or clays, which are now hardened and compressed into shales and sandstones. But if we have a marsh at one point which continued long enough to allow of the accumulation of vegetable matter sufficient for a considerable seam of coal, the presumption is that on that exact horizon we shall find that there were other areas above the water on which vegetation also grew, and thus along one water-line there be formed a seam of coal, varying in its fortunes of thickness and quality, ranging, with many interruptions, through many counties and perhaps hundreds of miles. A long period of rest from downward movement, such as the growth and accumulation of a thick seam of coal imply, almost necessitates the fact that, during that long period, wherever there were along the water-line areas of low-land, whether insular or continental fringes, on which vegetation might take root and grow, there would be such growth, and consequently a seam of coal. We, in fact, find this to be the case, so that, in tracing a seam of coal, we learn where the water spaces were, and where even the smaller channel-ways extended through the ancient marshes. These water spaces, wider or narrower, we are able to cross, preserving accurately the level, and thus find the coal at other points always in the same geological horizon.

When the subsidence took place, by which the marsh or marshes of one horizontal line were lowered beneath the water, the presumption is that such subsidence would be an even and regular one. We can hardly suppose that, within any limited area, there would be any considerable inequality in the sinking, any irregular plunges downward here and there, so as to tilt at various angles the plane of the coal. The subsidence was of course greater in some districts than in others. In Nova Scotia there are 14,570 feet of productive Coal Measures, with over 80 distinct seams of coal; in Eastern Pennsylvania 3000 feet are reported; while in Southern Ohio the highest coal-seam yet found is about 1500 feet above the Waverly sandstone, on which at places a seam of coal with its under-clay is found to rest, with no intervening conglomerate. It is also entirely possible that, when any *large areas* of any one coal-field are carefully investigated, it will be found that some portion of such large area may have had a some-

what more rapid subsidence than the rest.* But, as a rule, the subsidence was so regular that two seams of coal, each formed on its water-line, are found to present an almost perfect parallelism. For example, in Ohio, the Nelsonville seam of coal is found, in the vertical series, to be 420 feet below the Pomeroy seam. These two seams range through many counties, and everywhere the interval between them is exactly the same. The same is true of all other well-defined and continuous seams. One careful measurement of the interval between two seams is so excellent a guide that, either seam being found, the place of the other can be readily determined. There may be difficulty in ascertainiug the exact interval, because there may be considerable horizontal distance between the exposures of the seams, and calculations must generally be made for the dip, usually an unknown term; but when the measurements are accurate the parallelism is perfect and beautiful. There is a little play of variation sometimes, but it is generally very slight. In limited areas this could hardly be otherwise. Even in cases of earthquake action we generally find the areas of elevation or subsidence to be quite extensive. But there is no proof that in the Coal Period there was any intense earthquake action, nor any convulsive disturbances which would give to the plane of a coal-seam great irregularities in inclination. It must be remembered that the elevation of the Alleghenies and the foldings of the Appalachian region and all the thousand undulations given to our coal-fields were subsequent to the formation of our Coal Measures. The results of the most careful observations in all our coal-fields create a reasonable belief that the subsidence was semi-continental in character, and that the crust of the earth settled down in an even and dignified way.

So far as my own observations go, I have never found an instance where two distinct seams of coal came together, or conversely, where a seam becomes divided and its parts continue to diverge for a long or indefinite distance. It is not uncommon to find in a seam of coal the proof that the coal-marsh had in it local depressions, which were filled with sediment, making a soil on which new vegetation grew, and thus the seam shows two parts, separated by fire-clay, sometimes several feet thick; but in every instance, when traced, I have found the parts to re-unite. The two parts never diverge inde-

* I have myself reported a case of this kind in Ohio, during the earlier portion of the Coal Period, but the supposed proofs of this are undergoing careful revision.

finitely. From these statements we may infer a general law of parallelism. Such law is in harmony with the belief of the most careful observers, that our productive Coal Period was characterized by great quietness, and freedom from violent local disturbances.

Lesquereux, who visited the Dismal Swamp in Southeastern Virginia, reports that the Drummond Lake, which is fifteen feet deep, has beneath it the usual vegetable matter characterizing the bed of the surrounding swamp. Now, if this lake were filled up with earthy sediments and swamp vegetation should grow and accumulate over them, and afterwards the whole vegetable matter of the entire swamp were buried and changed to coal, we should have in the central area a divided seam or two parts of one general seam. If, by some more recent eroding agency, half of the whole area, including half of the area once occupied by the lake, were swept away, we might find the two parts of the seam of coal showing an increasing divergence to the point or line of erosion, and unless checked by deductions from previous observations, we might suppose the two parts to go on diverging indefinitely. There may be exactly similar cases in our coal-measures which mislead because we obtain a view of only a part of what constituted the original area of the seam. In the *Student's Elements of Geology*, as also in the *Elements*, Sir Charles Lyell brings forward an instance of the supposed coming together of seven widely different coal seams in Pennsylvania, and he explains, with the aid of a diagram, the method by which such union might be brought about. The explanation is by the subsidence of a part of a marsh and the silting up of the water over the submerged part, thus forming a new surface continuous with the not submerged. If such submergence is local—and he speaks of a "lagoon" in a swamp—the division of the main coal would be only a local duplication. But the coming together of widely different seams—each formed originally upon its own water level—not only involves unequal subsidence, but, what is more difficult of belief, that there was a limited area where all the seams met, which balances itself at the water's edge, while the adjacent area was sinking and filling up for new marshes, and this repeated, many times over. The following is Lyell's statement of the facts as he obtained them in his visit to the United States in 1841, from the late Prof. Rogers: "Between Pottsville and Lehigh Summit Mine seven (of these) seams of coal, at first widely separate, are, in the course of several miles, brought nearer and nearer together by the gradual thinning out of the intervening coarse-grained strata and their ac-

companying shales, until at length they successively unite and form one mass of coal between forty and fifty feet thick, very pure on the whole, though with a few thin partings of clay." When we come to examine the *Geological Report of Pennsylvania* by the late Prof. H. D. Rogers, we find that these several seams have not been *proved* by any stratigraphical observations to come together; they have not, by the comparisons of carefully measured sections at different points, been found showing a convergence, but we have in place of facts only a theoretical conclusion, adopted for the purpose of explaining the unusual thickness of coal at Summit Hill. I quote all Prof. Rogers says on the subject:

"The only question open to discussion is, whether in an instance like that of the huge mass of the Summit Hill Mines and Panther Creek tunnels, where the bed possesses very unusual thickness, the expansion of its size is caused by the merging into the principal bed of other adjoining coal seams through the thinning away of the dividing strata, or is merely a local enlargement of the one coal bed between the same roof and floor, arising from more aetive deposition at this spot of the vegetable materials which formed it. If we were in possession of any complete sections of the lower coal measures, such as those of the Nesquehoning and Tamaqua coals, illustrative of the condition of things nearer to the Summit Mine than those localities, we might, from such data possibly determine the running together or not of some of those beds to form this great deposit; but no intermediate points have been developed, and the distance of the two localities named, one 4½ miles and the other 5 miles, is too considerable to permit us to institute any close comparison between the individual beds at either of them and that of the Summit. To explain the unusual thickness of the great bed by the coalescing of several large seams of the Nesquehoning group, we must assume, if we take the "main lower coal" and the two next which overlie it, as those which have here come together, that there has occurred a total exhaustion of about 134 feet of included rock, or if we suppose only this "main lower coal" and the double or Rowland's coal to have united, we have still to conceive of the thinning out of 77 feet of sandstone in a range of only 4½ miles. A like difficulty besets us when we consider the thick plates of sandstone and slate which we must assume as having disappeared between the Little Schuylkill and the Summit if we would derive the great bed from the coming together of any two or more of the principal lower seams of that locality. Nevertheless, so much more uniform

are the coal beds generally than the mechanically derived sandstones —so much more easy is it when we advert to the respective circumstances under which these two classes of deposition originated, to ascribe a rapid variation of thickness to the wildly-strewn strata of sand and pebbles than to the slowly and gently accumulated layers of vegetation of the ancient carboniferous marshes—that I strongly incline to that view which assumes the apparent alteration of thickness to be due to the thinning out of the arenaceous rocks."

From this language it appears that no facts have been obtained by careful stratigraphical measurements to prove the actual coming together of the different seams of coal, but the union is assumed as on the whole the least difficult way of explaining the unusual thickening of the coal at the Summit. This, of course, is only the opinion of Prof. Rogers' and is entitled to all the weight which the opinions of so eminent a geologist should receive. It is readily granted that sands are accumulated along shore lines with great uneveness. This depends upon the strength of currents and the quantity of material. Along a shore there are places of comparatively quiet water, where finer sediments, now compressed into shales, are deposited, and we often find these shales alternating with sandstones. In Ohio on the same horizon I find sometimes 60 feet of sand rock and a few miles away 60 feet of shales. The marginal area below the water must be filled up with something and the uneveness of the resulting bedding of the sand rock or shales is not a matter of consequence, nor is it pertinent to the solution of the problem in hand, viz.: the explanation of the unusual thickening of a coal seam at a given point. The real difficulty is antecedent to the filling in of a submerged area by mechanical sediments, it matters not whether by "sand and pebbles widely-strewn" or by mud gently dropped in more quiet water. How came a part of a marsh with its coal-making vegetation 134 feet below its original level, while the remaining part of the marsh maintained such a wonderful statical equilibrium just at the water level? I do not say that this is impossible, but it is not probable, indeed it is so improbable that it may not be lightly inferred.

If we accept Prof. Rogers' theory of union of seams to form the great Summit seam, for example, the seams found at Nesquehoning, what are we to conclude becomes of the great aggregated seam as we go towards Tamaqua? The great seam has a geographical limit to its greatness. If its parts separate again and in their divergence constitute the Tamaqua coal seams, then we have the interesting fact

that a mere bit of an ancient marsh held itself bravely up above water while all around it the earth kept sinking, interrupted only by those long intervals of repose in which new marshes were formed, upon which grew the vegetation of the successive seams of coal. Such stability in the midst of instability is highly improbable. If, on the other hand, the great Summit seam is not thus divided into diverging parts, but gradually becomes thinner and extends towards Tamaqua, and is represented there by some smaller seam in that direction, then the question very properly arises—why, if a seam of coal may thin out toward Tamaqua may it not also towards Nesquehoning, and thus render unnecessary the assumption that several distinct and widely separated seams have coalesced?

It is much easier for me to believe that in this famous Pennsylvania case, now made historical by Sir Charles Lyell, the conditions of accumulation of a large mass of vegetable matter were more favorable at that part of the marsh now represented by the Summit Hill coal, than at other portions of the marsh. The conditions of growth might have been very different, or there might have been different degrees of waste from decomposition, or even by mechanical removal. Indeed all these causes might have combined to create the difference in the thickness of the coal. In Ohio I find a seam of coal from 4 to 5 feet thick and evidently retaining its original and normal thickness, while 3 miles away the same seam is nearly 13 feet thick. It is as easy for me to believe that a seam might at Nesquehoning be 28 feet thick, and at the Summit Hill be nearly 50 feet thick, as that a seam in Ohio should in a less distance change from 4 to 18 feet.

I am well aware that published sections, taken in a very limited area, sometimes show such a wide variation of intervals between so-called proximate seams of coal that any parallelism seems entirely out of the question. In one case, within the area of a county, where there were five seams of coal in the vertical series, the intervals between each two consecutive seams are given. The published figures show that, in the subsidence, before the second seam from the bottom was formed, the originally horizontal plane of the bottom seam had sunk to depths varying from 34 feet to 87 feet. Before the third seam was formed, the second horizontal plane of coal had sunk irregularly to depths varying from 47 feet to 149 feet. The third plane of coal, in turn, settled down in some places 31 feet and in others 69 feet before the fourth seam was laid down; while the plane of the fourth was found to show an irregular subsidence of from 13

feet to 40 feet before the fifth and highest marsh became ready for its luxuriant vegetation. It would be discourteous in me to question the accuracy of the identification of the seams or of the measurements between them. If these figures represent facts, they, with all facts, however stubborn, have their rights. These facts, however, appear to me to have unusual stubbornness. It is barely possible that where we have sands and clay sediments in horizontal alternation, filling the interval between two seams of coal, there might have been a slightly greater compression and condensation of the mass of soft sediments than of the sand, and hence the plane of the coal might show a trifling undulation. I have not, however, observed any such cases.

The buried vegetation of the coal-marshes reappears, after the lapse of long geological ages, in three pretty well marked varieties of coal, viz., the more bituminous or caking, the dry splint and the cannel—all grouped under the general head of bituminous as distinguished from the metamorphic anthracite. The more bituminous or pitch coal appears to be the natural or normal form which the unaltered vegetation took when buried. Any one familiar with the details of our bituminous coal fields, has often seen in the shales and slates films of this bright resinous coal, where single trunks or branches of *Sigillaria lepidodendra*, or of large ferns, like *Pecopteris arborescens*, have been buried with an almost perfect exclusion of air. Such films of coal are derived, as Dawson has abundantly proved, from the bark layers of the tree, the interior portion of the tree always, in these cases, disappearing without adding to the quantity of coal. The same high authority regards the mineral charcoal common in most seams of coal as the product of the partially decomposed inner bark, and of the more woody portion of the tree with portions of other vegetation. In some cases which have fallen under my observation, where there was reason to believe that the tree had been prostrated while a living tree and buried without any previous decomposition, both barks were converted into bright and resinous coal. From this we may, perhaps, infer that if the whole mass of vegetation forming a coal seam were completely buried without any previous decomposition, we might expect the whole to be converted into bright coal. Sometimes we find the coal very bright and pitch-like in a considerable portion of the seam, showing scarcely any mineral charcoal or laminations of duller color, which latter are generally supposed to indicate the more decomposed vegetable matter of leaves, fronds and smaller plants; but such cases are rare. Dawson thus writes: "I

would also observe that, though in the roof shales and other associated beds it is usually only the cortical layer of trees that appear as compact and bituminous coal, yet I have found specimens which show that, in the coal seams themselves, true woody tissues have been converted into structureless coal, forming like the coniferous trees converted into jet in more modern formations, thin bands of very pure bituminous material." The probability is that the less the subaërial decay, the more perfectly bituminized and structureless becomes the resulting coal. Nothing would be so likely to prevent such decay as immersion in water, and such immersion must play an important part in the formation of the more highly bituminous and coking coals. "In the putrefaction of wood under water or imbedded in aqueous deposits," says Dawson, "a change occurs in which the principal loss consists in carbon and oxygen; and the resulting coaly product contains proportionally more hydrogen than the original wood. This is the condition of the compact bituminous coal. * * * * The mineral charcoal results from sub-aërial decay, the compact coal from subaqueous putrefaction more or less modified by heat and exposure to air."

Prof. T. S. Hunt, in the *Canadian Naturalist*, July, 1861, gives the results of the analyses by various chemists, taken chiefly from Bischof's *Chemical Geology*, showing the relative proportions of the elements in wood, peat, coal, asphalt and petroleum. He states that "the nitrogen, which, in most cases, was included with the oxygen in the analysis, has been disregarded, and the oxygen and hydrogen, for the sake of comparison, have been calculated for twenty-four equivalents of carbon."

1. Vegetable fibre or cellulose, ...	$C_{24} H_{20} O_{20}$
2. Wood, mean composition, ...	$C_{24} H_{18 \cdot 4} O_{16 \cdot 4}$
3. Peat (Vaux), ...	$C_{24} H_{14 \cdot 4} O_{10}$
4. " (Regnault), ...	$C_{24} H_{14 \cdot 4} O_{9 \cdot 6}$
5. Brown coal (Schrötter), ...	$C_{24} H_{14 \cdot 3} O_{10 \cdot 6}$
6. " (Woskresensky), ...	$C_{24} H_{13} O_{7 \cdot 6}$
7. Lignite (Vaux), ...	$C_{24} H_{11 \cdot 3} O_{6 \cdot 4}$
8. Lignite passing into mineral resin (Regnault), .	$C_{24} H_{15} O_{3 \cdot 3}$
9. Bituminous coal (Regnault), ...	$C_{24} H_{10} O_{3 \cdot 3}$
10. " "	$C_{24} H_{10} O_{1 \cdot 7}$
11. " "	$C_{24} H_{8 \cdot 4} O_{1 \cdot 2}$
12. " "	$C_{24} H_{8} O_{0 \cdot 9}$
13. " (Kühner and Gräger), .	$C_{24} H_{7 \cdot 4} O_{1 \cdot 3}$

14.	Bituminous Coal (mean comp.), (Johnston),	$C_{24}\,H_9\,O_3$—O_4
15.	Albert coal (Wetherell),	$C_{24}\,H_{15 \cdot 9}\,O_{1 \cdot 8}$
16.	Asphalt, Auvergne,	$C_{24}\,H_{17 \cdot 7}\,O_{2 \cdot 2}$
17.	" Naples,	$C_{24}\,H_{14 \cdot 6}\,O_2$
18.	Elastic bitumen, Derbyshire (Johnston),	$C_{24}\,H_{22}\,O_{0 \cdot 3}$
19.	Bitumen of Idria	$C_{24}\,H_8$
20.	Petroleum and Naphtha,.	$C_{24}\,H_{24}$

These analyses are very attractive and valuable.

It is an interesting fact that the beautiful, smooth, vertical planes, which are found, more or less, in all coals, and which, in the same seam always having a uniform direction, determine the "face" of the coal, are far more abundant in the more resinous or pitch-like varieties. The thin pellicles of bright coal formed when a trunk of *Sigillaria* or other tree is buried in the slates, show these planes in great perfection and profusion. In whatever way the tree may lie, these vertical joints, if joints they may be called, always maintain a constant direction with reference to the points of the compass. In the coal-seams of Southern Ohio, the direction of these planes is proximately east and west, the variation not often being greater than 15° north of west and south of east. In West Virginia, I have found a seam of coal in which these planes held a northwest and southeast direction. The splint or black coals of Clay county, Indiana, are said to have two sets of such planes crossing each other, so as to give the blocks a slightly diamond shape.

The *splint coal* possesses a less pitch-like character, is more laminated in structure, and generally contains more mineral charcoal. The laminæ are harder and tougher and much more difficult to break. The fracture of the coal is sharply ragged and splintery and never vertical, as in the case of the more bituminous and shining varieties. It is evident that the vegetation was more exposed to alternate conditions of wet and dry, was thoroughly leached and brought thereby into a condition of fibrous toughness. Such coal compares with the more bituminous and pitch-like coal as wrought-iron compares with brittle cast-iron. The splint coal separates into large and firm tabular plates, which return to the blow of hammer a sound almost metallic in character.

Sometimes a seam of coal passes, by almost imperceptible gradations, from the highly bituminous into splint, and in a few instances I have found layers of each alternating in the same seam.

The splint coal is always an open and dry burning coal. It never

melts and swells in the fire like the caking variety, and for this reason it is specially adapted, in the raw state, to the smelting of iron.

Cannel coal. We should expect that in the swampy flats of the Coal Period there would be wet places filled with muck or vegetable mud, similar to what we often find in such swamps to-day. In the modern muck-bog the structure of the vegetation, through chemical reactions, is almost entirely obliterated, and there results a fine soft mud, which, when dried, forms a dark and almost impalpable powder. We find the proof of the existence of similar locations of vegetable mud in the old coal-producing areas. They were probably not the only wet places, for what has already been said of the origin of the more bituminous or pitch-like coals implies the existence of much water, but they were the wet places in which the vegetation became so thoroughly decomposed that when afterward buried, compressed and bituminized, it was changed into a hard compact stratum of coal, showing little lustre, generally no lamination, and breaking with conchoidal fracture. It is probable that there were vast quantities of vegetable mud formed which did not go to constitute seams of cannel coal, but were floated away by currents, and mingling with mineral sediments settled in the more quiet waters of the shallows, thus forming strata of bituminous slates and shales. Such strata are very common and, when carefully traced, are generally found to align themselves on the geological horizons of seams of coal. Hence, they serve as excellent guides as we traverse the breaks of continuity in a coal seam.

Göppert, in some experiments, found that "mosses lying 6 or 8 inches under water were decomposed rapidly, while those from 1 foot to 3 feet below the surface were tolerably preserved for 15 months." This fact would make it not improbable that it was chiefly in quite shallow water that the muck-producing decay took place, while the "subaqueous putrefaction" of the vegetation forming the pitch coal, spoken of by Dawson, required a deeper submergence and a more perfect exclusion of the air. In the water over the accumulating vegetable mud, fishes, molluscs and other forms of life sometimes abounded, and these were entombed in the mud.

(To be continued.)

ON SOIL ANALYSES AND THEIR UTILITY.

(*Abstract of a Paper read at the Dubuque Meeting of the Am. Ass'n Adv. Science, by* EUGENE W. HILGARD, *State Geologist of Mississippi.*)

In this paper the author reviews the objections against the utility of soil analyses, as set forth by Prof. S. W. Johnson, of Yale, in an article published in the American Journal of Science for Sept., 1861. He states that, while agreeing with Prof. Johnson in many of his strictures, he thought some of the objections urged inapplicable to large classes of soils in the South and West, while others were avoidable. With this view he had continued, or caused to be continued, the analytical researches already carried on for some time on the soils of the State of Mississippi. From the results obtained in the analyses of over 200 soils and subsoils, he concludes that highly important practical information can be derived from series of analyses, carried out upon a uniform plan, upon soils directly derived from uniform or uniformly variable formations, as is the case to a great extent in the South and West. The cardinal objection, that representative specimens cannot be obtained, however weighty in mountainous districts and on manured soils, becomes untenable on the prairies and even in the rolling uplands of the South, provided due care is exercised in sampling the soil—an operation second in difficulty only to the analysis itself, and not to be trusted to inexperienced hands.

For the purposes of soil analysis no commercial reagents can be used, since however pure they may have been when originally prepared, the acids, ammonia, etc., become contaminated when kept in glass bottles for a length of time. All liquid reagents used must be specially prepared in small quantities as required. The solvent to be used should not go as deep as H F, or fusion with alkaline earths; nor fall so far short of what the rootlets of plants can perform in the way of solution as carbonic acid. Hydrochloric acid of uniform strength, sp. gr. 1·11 to 1·12, as obtained by steam distillation, was used in all analyses for a uniform length of time, and all operations were performed in as uniform a manner as the variety of materials permitted.

We can thus obtain *comparative* and *comparable* data, giving not the entire amounts of nutritive soil ingredients present, but the amounts respectively accesible to the action of one and the same degree of solvent action, supposing, of course, the nature of the materials to be substantially the same. We can thus compare, not any

two soils from distant localities, but series of soils of essentially similar origin.

The object being, not an exhaustive determination of *all* the physical and chemical characters of the soil, but something practically analogous to the assay of ores, the chemist should on the one hand be relieved from the numerical determination of such factors as can, with sufficient correctness, be estimated comparatively, while on the other hand he should avail himself, in the practical interpretation of his results, of all that an accurate study in the field, coupled with whatever experience may have been acquired by cultivators, can afford in the way of facts and suggestions. Mere columns of figures can be of little value except as showing a great excess or scarcity of some important ingredient.

Of the latter, *potash, phosphoric acid* and *lime* are those whose presence in greater or less quantity chiefly determine the chemical value and character of the soil; vegetable matter or "humus" must also be accurately determined, since upon it, as well as upon the clay present, chiefly depends the important absorptive power both for ammonia and moisture.

The results of silt-analysis being as inadequate to determine that factor as is the chemical composition, the direct determination of the absorbing power for aqueous vapor has been studied, with this result: that for the ordinary range of temperature in a saturated atmosphere, the co-efficient of absorption is sensibly constant for one and the same soil, being for—

Very sandy soils, . .	1·5 to 2·0	per cent.
Loam soils, . . .	5·0 to 8.0	"
Heavy clay soils, . .	12·0 to 15.0	"

These numbers, representing with tolerable accuracy what is practically expressed "heaviness" and "lightness;" large amounts of humus and ferric oxide, however, interfere occasionally with the practical correctness of the estimate so formed.

The author's conclusions may be summed up thus:

1. While the analysis of *cultivated and manured* soils can seldom give us information of much practical value, from the difficulty of obtaining representative specimens; the same is not true of the impalpable virgin soils directly derived from widespread quaternary formations, as is extensively the case in the South and West. The soils of large tracts of country can thus be classified into a few typical ones and their intermixtures.

2. Series of analyses of representative specimens, made on a uni-

form plan and interpreted in connection with all local circumstances, and experience had in cultivation of similar soils, can furnish information of great practical value concerning the native fertility, treatment in cultivation, and modes of improvement. They serve—

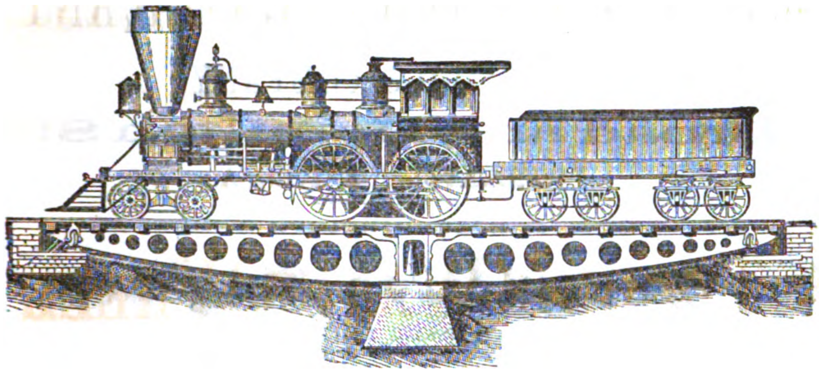
a. To *identify* as well as to *distinguish* from one another the soils of different localities, rendering the experience had with them at other points applicable in the selection and cultivation of new lands.

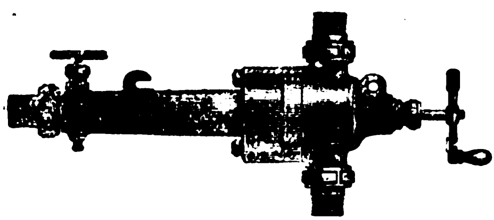
b. To demonstrate a great abundance or extreme deficiency of important ingredients, showing *which* of necessity will require to be added in manures, and *which* may be developed by stimulants or by the fallow.

c. Inasmuch as in soils of similar origin the decomposition of the minerals may be presumed to have advanced to a similar extent, the amounts of nutritive soil ingredients extracted therefrom by the same solvent under identical circumstances will be more or less accurately the measure of their native fertility, and of their duration in the process of exhaustive cultivation. This presumption receives strong confirmation from the results of the analyses of Mississippi soils.

d. The some analyses show that, *cæteris paribus*, the thriftiness (i. e., immediate producing power) is sensibly proportional to the amount of *lime* present, while (again *cæteris paribus*) the duration under exhaustive cultivation is proportionately diminished. This is what might have been anticipated, but is a highly important practical intimation.

4. Finally, the author contends that the omission of such investigations from the work of geological surveys is a grave one, not justified either by the plea of their costliness or of their want of utility, and the more to be regretted, as within a few years it may be impossible to obtain representative specimens of the best soils in their virgin condition, and because such researches require a comprehensiveness of plan not to be attained save under the shadow of a public work. The agricultural colleges will have to take up again, under great disadvantages, the work thus neglected by the State surveys. The objections that have been raised against the utility of soil analyses would, if applied to other departments of research, have debarred us from some of the most important discoveries, and are not of sufficient weight to justify us in giving up all hope of being able to understand and control the mode of action of the several kinds of soil. We assuredly can never hope to advance therein *without* analyses. He, therefore, calls upon the geologists of other States to rectify the omission before it is too late and a legislative *fiat* declares their labors to be "finished."





THE BOYDEN PREMIUM.

URIAH A. BOYDEN, ESQ., of Boston, Mass., has deposited with the Franklin Institute the sum of one thousand dollars, to be awarded as a premium to

"Any resident of North America who shall determine by experiment whether all rays of light, and other physical rays, are or are not transmitted with the same velocity."

The following conditions have been established for the award of the premium:

1. Any resident of North America, or of the West India Islands, may be a competitor for the premium; the southern boundary of Mexico being considered as the southern limit of North America.

2. Each competitor must transmit to the Secretary of the Franklin Institute a memoir, describing in detail the apparatus, the mode of experimenting, and the results; and all memoirs received by him before the first day of January one thousand eight hundred and seventy-three, will, as soon as possible after this date, be transmitted to the Committee of Judges.

3. The Board of Managers of the Franklin Institute shall, before the first day of January, one thousand eight hundred and seventy three, select three citizens of the United States, of competent scientific ability, to whom the memoir shall be referred; and the said Judges shall examine the memoirs and report to the Franklin Institute whether, in their opinion, and, if so, which of their memoirs is worthy of the premium. And, on their report, the Franklin Institute shall decide whether the premium shall be awarded as recommended by the Judges.

4. Every memoir shall be anonymous, but shall contain some motto or sign by which it can be recognized and designated, and shall be accompanied by a sealed envelope, endorsed on the outside with same motto or sign, and containing the name and address of the author of the memoir. It shall be the duty of the Secretary of the Franklin Institute to keep these envelopes securely and unopened until the Judges shall have finished their examination; when, should the Judges be of opinion that any one of the memoirs is worthy of the premium, the corresponding envelope shall be opened, and the name of the author communicated to the Institute.

5. Should the Judges think proper, they may require the experiments described in any of the memoirs to be repeated in their presence.

6. The memoirs presented for the premium shall become the property of the Franklin Institute, and shall be published as it may direct.

Contents for January, 1873.

Illustrations—Six Plates and Nine Woodcuts.

EDITORIAL.

THE
JOURNAL
OF THE
FRANKLIN INSTITUTE

DEVOTED TO

SCIENCE AND THE MECHANIC ARTS.

EDITED BY

WILLIAM H. WAHL, PH. D.

ASSISTED BY THE COMMITTEE ON PUBLICATIONS.

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1873.

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OF THE

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(Established 1826.)

DEVOTED TO SCIENCE AND THE MECHANIC ARTS.

This Journal is issued in monthly numbers of 72 pages each, and regularly contains original matter of interest to the Engineering and Scientific professions, and to the Manufacturer.

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JOURNAL

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OF THE STATE OF PENNSYLVANIA.

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LXV.] FEBRUARY, 1873. No. 2

EDITORIAL.

ITEMS AND NOVELTIES.

An Improved High Pressure Alarm.—At the recent exhibition of the American Institute of New York, amongst the numerous mechanical novelties presented for public inspection was the ingeniously constructed alarm herewith illustrated and described. The instrument was patented during the last year, by Messrs. Jewell & Steele, of Brooklyn.

In the accompanying plate, A (Fig. 2) represents the valve, which is conical in shape and expanded above, to form a hollow chamber into which lead can be poured to weight it, or, as is the case in Fig. 3, it can be cast solid. About the valve seat is the plate, B, shown in detail in Fig. 5, the lower side being presented to show the two ports, C, through these openings; when the valve is but slightly raised, enough steam escapes to prevent any further rising of the valve until a greater pressure has accumulated in the boiler. The size of the posts and the weight of the valve may manifestly be so regulated as to bring about this action at any desired pressure. For example's sake, suppose 30 pounds, with a margin of three pounds to the pressure which the engineer is allowed to carry in his boiler. When the first figure is reached, the steam escapes through the ports, C

(Fig. 5), passing up through the annular spaces D (Fig. 6), to the whistle to warn the attendants that the pressure is approaching its limit.

Should the engineer permit the margin of three pounds to accumulate, the instrument performs another function. A weighted lever (Fig. 7), rests with one end beneath the shoulder of the valve weight (Fig. 2). As the valve rises, the counterpoise of the lever, E, descends, turning the lever on its pivot. This pivot carries also the arm, F. This last carries a pawl, G, which in turn operates a toothed wheel, to the axis of which is attached a pointer, moving over a dial plate (Fig. 1). This pointer or tell-tale is moved over the dial a distance of one tooth in the wheel for every time the attendant reaches or exceeds the margin of pressure. As the wheel only acts through a portion of its arc, it is impossible to work the tell-tale around to its original position, by surreptitiously allowing the pressure to rise to the required height a sufficient number of times.

Again, if the margin of three pounds be exceeded, and the pressure is run up, for example, to 35 pounds, the valve will be so much raised as to permanently lock itself in that position.

This motion is accomplished in the following manner. On the inner side of the outer shell (figs. 2 and 6) is turned a groove, H, into which the slide I enters as soon as the valve has been raised high enough, the slide being operated by the weighted lever, J, (fig. 6), or by springs as in figs. 3 and 8. These slides suspend an auxiliary weight, K, which from that time will not act again until the instrument has been opened and its parts readjusted. The careless attendant now finds that he cannot carry within five pounds of the pressure he was permitted to employ, without constantly sounding the alarm, thus calling attention to his fault, for the commission of which any suitably severe penalty may be exacted. The cap of the whistle is locked on the inside by the screw L, (fig. 2), and the cap of the valve is securely fastened by the rod M and lock N, leaving the attendant no other resource than to report the condition of things to head quarters. Another form of the valve, shown in fig. 4, has the valve weighted with shot, confined in the chamber by a disk, O, of fusible metal. The valve in first rising would sound the alarm, when, if neglected, the increasing heat and pressure will heat the fusible disk to such an extent as to melt it. The shot escaping from the chamber, so lighten the valve that the alarm will thereafter sound at a steam pressure much below that which the engineer is permitted or

Fig 1

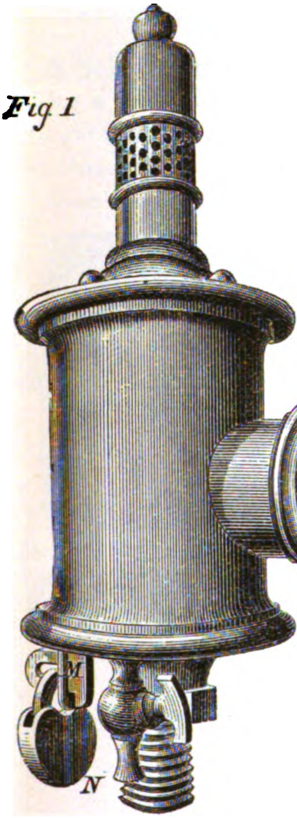


Fig 2

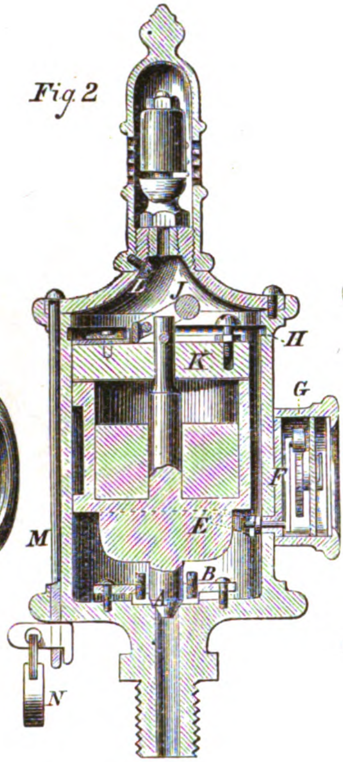


Fig 3

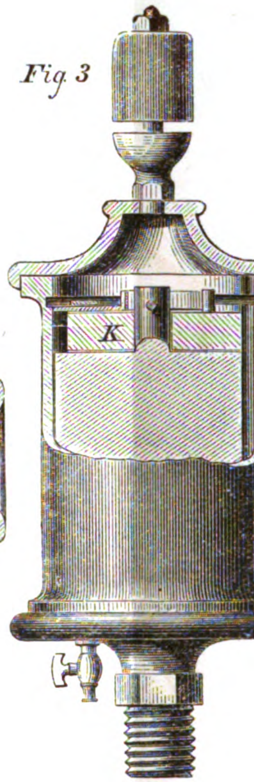


Fig 5

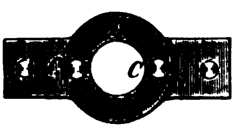


Fig 6

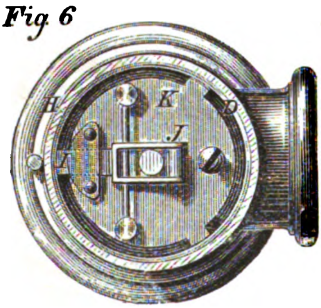
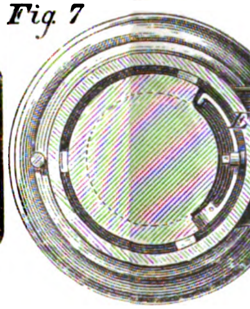


Fig 7



AN IMPROVED HIGH-PRESSURE ALA

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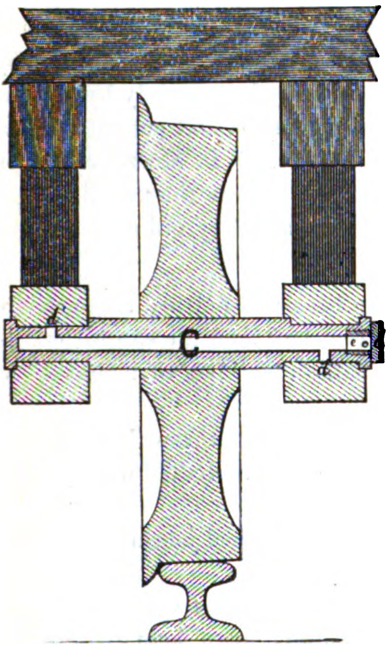
desired to maintain. By the series of automatic movements here briefly described, the inventors have sought to surround the attendant with all the possible inducement to keep him always watchful and attentive to his duties.

A Self-Lubricating Axle.—The accompanying engraving illustrates a method of effecting the automatic lubrication of car-axles; designed and patented by Mr. Edward Williamson, a member of the Institute.

Each wheel is supplied with an independent axle, having its bearings in journaled boxes arranged between the ends of standards in the usual manner. The axle, C, is tubular, and has the inner end permanently closed, while the outer end is closed with a screw. The object of the hollow axle, is to afford within the wheel a reservoir of oil, which shall be supplied to the bearings automatically so long as the wheel is in motion. In order that the lubricant shall reach the bearing surfaces, it will be observed that the axle is provided with two openings, (*d d*,) at both ends and in opposite positions. The shank of the screw is made tubular and is supplied with an opening coinciding with that in the end of the axle. Another small aperture, *o*, in the screw permits the oil to be supplied to the reservoir, (C), by slightly loosening the screw.



The design of the inventor, as will already have been perceived by the reader, is to feed the lubricant upon the bearings automatically by centrifugal force; furnishing to the same a greater supply when the wheel is in rapid motion, and a diminished supply when the motion of the wheel is lessened, when less would be required.

The device is founded upon a simple and scientific principle, and if found to answer the purpose in practice, will become extremely useful.

Crank-shafts.—As many readers of the "Journal" are aware, the construction of this part of marine engines, especially when of the largest size, always has been attended with difficulties, as well during the finishing as the forging; the chief one, after a sound forging has been produced, being that of turning the three or more journals on it accurately in line with each other. In the endeavor to avoid these troubles, some engineers use what are termed "built-up crank-shafts," the cylindrical and flat parts, or "throws," being forged and finished separately, and then put together in the manner deemed best by the builder. The crank-shafts for the four pairs of compound engines for the vessels "Pennsylvania," "Ohio," "Indiana," and "Illinois," of the American Steamship Company, now building by the Wm. Cramp & Sons Company, were forged separately by Messrs. Seyfert, McManus & Co., and are being finished and put together at the Port Richmond Iron Works of Messrs. J. P. Morris & Co., in the following way, which it is thought will secure the parallelism of the three journals as nearly as can be obtained by ordinary tools of the machine shops:

The flat parts, or "throws," having been tool-finished all over, are bored, the hub to a shrinkage fit, for the shaft, and the eye for crank-pin roughed out to a diameter about half an inch less than that of the crank-pin.

After the key ways are cut nearly to size, the "throws" are heated and shrunk on the shafts, when the key ways are drifted out, and the keys driven hard and the ends dressed off.

Two half shafts (one "throw" and its attached journal), are then placed in a machine made thus:

A heavy cast-iron plate, 12 feet long and 4 feet wide, having its top surface planed true, is laid horizontally upon heavy imbedded timbers. Upon this are secured immovably four pillow-blocks, at proper distances apart; in line with these and beyond them are two temporary bearings, used for supporting a stiff boring-bar carrying a sliding cutter-head, which bores successively the four pillow-blocks in line.

The temporary bearings are then fixed immovably, in line with the four just bored, at a distance equal to that between the centres of the main journals and crank-pin. Two half shafts are then set in the four pedestals, with the "throws" towards each other, just as they are to be when completed, and the eyes in line with the bore of the

two temporary bearings or side pedestals, when the caps are screwed down hard.

A boring-bar is then passed through the eyes of the "throws," and placed in the side pedestals, and the crank-pin eyes bored out, the one on the right hand a little larger than that on the left. Before the fine finishing cut has been taken very careful measurements are made to test the parallelism of the bar and the shaft, and also to determine whether the shafts themselves are accurately in line, or have yielded under the strain of their own weight (14 tons) or the action of the working parts. The boring-bar and its bearings are then removed from the plate. The crank-pin is then turned to a shrinkage fit for each "throw," the end fitting the left-hand "throw" a little smaller than the other. This allows it to pass through the right-hand "throw" until the end brings up against the "throw" in which it belongs. A portable hydrostatic press is then placed so one plate bears against the left-hand "throw," and the other plate against the end of crank-pin, and distance-pieces fitted between the "throws." The pin is then forced into position, the key ways drifted out, and the keys driven hard and ends dressed off, and the shaft is ready to go into its place.

Small crank-shafts have been fitted in the same way by the Port Richmond Iron Works, with very satisfactory results.

These now spoken of being unusually heavy, a correspondingly increased care was observed in their manipulation, and it is believed that they are as near "true" as it is possible to make them. W. J.

New Style of Testing-Machine.—A new machine for testing the strength of metals, manufactured by Riehle Brothers, of the Philadelphia Scale Works, has been exhibited during the last few days to a number of scientific and practical mechanics and engineers. Some years ago the United States government made experiments which have served as the base for estimates of the strength that an iron beam may be expected to possess. It was found that an iron beam of uniform thickness of one inch fixed horizontally, with one end only supported, would break at a weight of from 507 to 980 pounds for American iron, and from 472 to 770 for English iron, the weight being applied one foot from the supported end. If both ends of the beam are supported, it will bear six times the weight that can be placed upon it with only one end fixed, and the strength of beams is in direct ratio with their width, in reverse ratio with their length and

in the ratio of the square of their depths. From the experiments thus made with perfect iron, the strength of materials was formulated; but practical experience showed that large forgings and castings were subject to blow-holes and honey-combs, which the most vigilant inspection would fail to discover—and these defects would lead to breakage at points of strain where theory said that the metal should bear the given pressure. The matter became of so much importance in view of the large number of iron girders used in modern buildings, that in New York a law was passed requiring an actual test of beams, girders, &c. The machine exhibited by Riehle Brothers is designed for testing practically the tensile strength of bridge bolts, wire and hemp rope, chains, &c., in any lengths, beside boiler plate and other materials, and also to test specimens of any substance by compression. It can be so arranged as to test the resistance of iron and stone columns by crushing, girders by transverse strain and any material by any strain, including torsion. The parts of this ingenious contrivance are so arranged that the weighing levers are at one end, and the power, which consists of a hydraulic pump and jack that run upon wheels along a horizontal track, is at the other end. The strain is applied by the pump and jack which are used to take up the slack, and not to determine the amount of tension, as in most other machines of this kind. The tension is found by means of the weights which are placed on the disk suspended from the beam, and an ordinary one-pound weight will apply a strain of 1000. Accurate results can be obtained from 75 pounds to 75 tons. The machine is in equipoise before the specimen is in place, and is so nicely adjusted, that when a strain of 50 or 75 tons is being made, a half-ounce weight will instantly turn the beam and break the specimen if the necessary strain has been reached. The machine now on exhibition is capable of almost indefinite extension, and will be made 90 feet long. It is intended for E. B. Wood, Esq., of Detroit, Michigan. About twenty machines have thus far been manufactured (one for the United States government), and they have been sent to Cleveland, Cincinnati, Canada, and other places.

An Improved Tool for Turning Metals.—Before a recent meeting of the Institution of Mechanical Engineers, at Birmingham, Col. Clay, of Liverpool, read a paper "On an Improved Construction of Tool for Turning Metals at increased Speed."

This tool has one or more holes drilled through it up to its cutting edge, through which a jet of water is delivered underneath the shaving that is being cut, and upon the cutting edge of the tool, for keeping

it cool in working. By this device the tool is much more effectually cooled than by the ordinary plan of a drop of water falling upon the upper surface of the shaving, in which case little or no water reaches the point of the tool itself. The result of cooling the tool by delivering the water jet direct upon the cutting edge, is that the surface speed of the tool can be increased as much as four times in heavy cuts, and light cuts can be taken at as much as eight times the speed that is practicable with ordinary tools, without any risk of the temper of the cutting edge being destroyed by over-heating. It was stated that the plan had been tried in practice with perfect success.

New Steamship for Laying Cables.—A project which, if consummated, may effect an important decrease in the expense of laying submarine telegraphic lines, is said to be in prospect; a cable manufacturing company of England having the design of building a steamship expressly fitted for their work. This vessel, it is proposed, shall be smaller than the Great Eastern, and much less expensive to run, and shall be capable of carrying 3000 to 4000 miles of cable.

The Niagara Suspension Bridge.—A doubt having arisen as to the safety of the Niagara Suspension Bridge, the directors of the Great Western Railway ordered an investigation to be made. The caps on the towers covering the cables have been removed, and the cables found to be as perfect in all respects as ever they were. But, most important of all, the anchorage of the cables was thoroughly inspected. The masonry over one of them was removed for about twelve feet, or below where the wire is attached to the anchor chains. A portion of the cable is imbedded in water lime cement. For twenty years this has been there, yet, on removing it and rubbing the paint off the wires, the latter were found as bright and perfect as when placed there, the cement having preserved the wire and anchor chains intact. The examination was made in the presence of competent engineers, who have expressed themselves as above to the directors of the bridge company.

Canadian Wooden Railways.*—The wooden railroads built in the vicinity of Quebec have deservedly attracted much attention. The following data regarding them was given to us by Mr. Hurlburt, the projector and contractor of several of these roads. There are now over a hundred miles in operation. The gauge is 4 ft. 8½ inches.

* Railroad Gazette.

The running time is about 16 miles per hour, but trains have been run at the rate of 35 miles per hour. The rails are made of maple, 4x7 inches, set up edgewise, and notched into the cross-ties 4 inches deep, and held by two wedges down in the notch on the outside of the rail. The ties are 8 inches thick, and laid 20 inches apart. The cars have four wheels, and some of the engines weigh 30 tons. In frosty weather the driving wheels have less adhesion than on metal rails, but no considerable difficulty is experienced from this cause. Tho rails will last from two to four years, according to the quality of the timber and the amount of traffic. The cost of such roads is from four to seven thousand dollars per mile. They seem to be very well adapted for light traffic, and as soon as the business of such lines may require it, metal rails may be substituted for wood without any change in the equipment.

The Union Passenger Depot at St. Louis.—Alluding to the magnificent bridge across the Mississippi at St. Louis, a local paper gives the information that contracts have already been effected with the several railroad companies which secure to the bridge company an average tariff of 65 cents per ton; this item of freight alone yielding a yearly revenue of upwards of $500,000. From other sources it is estimated that not less than $300,000 will be received; thus affording the bridge company a yearly revenue of $800,000, or 8 per cent. on a capital of $10,000,000.

Simultaneously with the completion of the bridge will arise the necessity for a Union passenger depot at St. Louis, to accommodate the several roads leading into that city. The plans for this structure, which is prospected upon a scale of unusual magnificence, we are told have already been approved, and its erection will be inaugurated at no distant day. The part allotted to the railroads is designed to be as complete as possible. It is proposed to employ smoke-consuming engines for the purpose of running the trains into and out of the tunnel and depot. The floors will be deadened, and the trains will be operated by signals.

Marine Photometry.—A correspondent of the New York *Herald*, accompanying Professor Agassiz's expedition on the coast survey steamer *Hassler*, gives a brief but interesting account of an apparatus for determining the relative transparency of the sea at different places, which has already been employed by the expedition at Barbadoes and about the Galapagos Islands. A strip of board, about four inches

wide and four feet long, divided into a scale of ten equal intervals, is painted a dark lead color at one end, fading into white at the other. A large white board having been fastened parallel to it, and at a measured distance below it, the whole arrangement is lowered horizontally into the sea. At the dark end, the upper board appears the darker, but at the white end, the lower board, being seen through a greater depth of water, gives the darker appearance, and, of course, at some intermediate division, the two boards appear to be of the same shade. At that division the relative whiteness of the boards is evidently a measure of the percentage of light absorbed while going down and up again through the distance by which the boards are separated. This relative whiteness is readily estimated at night in the cabin by placing the boards at unequal distances from a candle so as to make them of the same apparent shade at the given division of the scale.

The illuminating powers are to each other as the squares of the distances of the boards from the light. Having once ascertained what percentage of light goes through a fathom, the proportion of daylight which reaches any given depth in the sea can be readily calculated. Suppose, for example, that one-half the light penetrates one fathom; then one quarter goes down two fathoms; one-eighth, three fathoms, and so on indefinitely.

This apparatus is the invention of Dr. Hill, who regards it as still in a crude form and capable of much improvement.

New Method of Cleaning Glassware, etc.—By Dr. I. Walz.—The cleaning of beakers and other chemical glassware that have contained oils, fats and similar organic matters, by means of potassium bichromate and concentrated sulphuric acid, is often inconvenient on account of the shape of the vessels, or because sometimes requiring the application of considerable heat, and thus causing breakage. The following method has given me uniformly satisfactory results: The vessel to be cleaned is filled, or, if large, rinsed with a moderately dilute solution of potassium permanganate, the contact of the liquid being prolonged till a film of hydrated manganic oxide has been deposited; the solution is then poured away, and the glass vessel rinsed with some strong hydrochloric acid. Chlorine is then formed, but not enough to cause inconvenience; and acting *in the nascent state* on the organic matter, it speedily converts them into substitution products, that are soluble in the slight excess of acid or water.

The water of the above also communicates the following description of a *a curious experiment with mercurous nitrate.* A few drops of strong mother solution from the crystallization of mercurous nitrate (proto-nitrate of mercury) are placed into a porcelain capsule; a little mercury is added and divided by means of a glass rod into a number of minute globules. The solution soon begins "to set" around the globules of mercury, and the latter are forced to the top by a kind of capillary action. If the right proportions have been chosen, and this is very easy to do, tubular vermiform formations will begin to grow out of the semi-solid mass in serpentine windings, each bearing a shining little globule of mercury at the end of the tube. Sometimes they grow very rapidly and attain a length of several inches. I have repeatedly prepared this experiment before going home in the evening, and on the morrow found the capsules filled with what appeared like a large number of tiny snakes' heads of silver, in every position of repose or motion.

A Chemical Experiment.—An experiment involving a molecular change in the condition of an element, can be performed as follows:—Let a copper and platinum strip form respectively the negative and positive terminals of a galvanic circuit; immerse these in a hydrochloric solution of chloride of antimony. The result of the galvanic action will be the precipitation of the antimony in form of a fine impalpable powder upon the surface of the copper, from which, when enough has accumulated, it may be readily removed by bending the copper strip back and forth. The metal thus obtained, if placed in a mortar, and vigorously triturated in with the pestle, will detonate with some violence, the explosions being at the same time accompanied with the evolution of light and heat. This curious phenomenon appears to be purely the result of a molecular change, induced in the metal by the mechanical force employed; the consequence being the conversion of the amorphous powder to a crystalline condition. It would be of some interest to note whether the same result would follow the application of heat to the powder, since, from the announcement of Bunsen, made some years ago, the metals rhodium and iridium, when deposited from solutions of their salts in an analogous manner, manifest this property in an extraordinary degree; so much so, indeed, that the scientific world came very near losing the invaluable services of its illustrious discoverer in consequence of a severe accident which befel him from this very unexpected source. It would be

a matter of no little interest to trace the analogy here indicated, to one of positive identity in kind, by investigating the behavior of such precipitated antimony when heated, as was the case with the platinum metals experimented upon by Bunsen.

Friction of Journals and their Proportions.—In its issue of January 11th, 1873, the *Scientific American* has the following article relating to the friction and proportions of journals, which we think worthy of republication in the *Journal of the Franklin Institute:*

"The friction on any surface, whether plane or cylindrical, is proportioned to the weight resting upon it and is not at all affected by the area of the rubbing surface, providing the pressure is not so great, on the one hand, as to change the character of those surfaces, nor so light, on the other hand, as to make the resistance principally that of viscosity of the lubricant rather than that of true friction. In the former case, the friction may increase immensely in consequence of the cutting of the surfaces; and, in the latter, the increase of frictional resistance will be approximately proportional to the increase of area.

"The work done in any given time, that is, the power wasted in turning any journal on its bearings, is, where the frictional resistance is the same, proportional to the speed of the rubbing surfaces, since it is measured by the product of the resistance into the distance through which that resistance is overcome. Therefore, it follows that a very large journal absorbs a larger proportion of the driving power of a machine than does one of small diameter, and in designing machinery we should make journals of as small diameter as possible without danger of breaking the shaft, or of causing abrasion of the rubbing surfaces.

"Again, the tendency of a journal to heat is the greater, the greater the pressure per square inch of longitudinal section of the journal, and it is increased by increasing the speed of the rubbing surfaces. Therefore, to make journals safe against heating, make them of as small diameter as safety permits; and having thus reduced their absorption of power to the lowest limit, secure bearing surface by giving them ample length. If they are, however, made so long that the shaft can spring in the journal, heating may occur from that cause; in line shafting, this will, of course, not happen. The best practice gives line shafting for mills a length of journal equal to four times the diameter of the shaft.

"There are rules, known to engineers, for properly designing journals, which are based on the principles above stated. The earliest of which we have knowledge is that of Professor R. H. Thurston, which was based upon observation of the action of crank shafts of naval steamers in 1862. A somewhat similar rule, based on locomotive practice, was published by Professor W. J. M. Rankine, in 1865. The first is expressed as follows:

$l = \frac{PV}{60000\ d}$; and $\frac{P}{ld} = \frac{60000}{V} = p$. The second is, $\frac{44800}{V \text{ plus } 20} = p$; and, when reduced to the same form as that of Professor Thurston, becomes $l = \frac{P\ (V \text{ plus } 20)}{44800\ d}$.

"Here l = length of journal in inches; P = total pressure on journal; p = pressure per square inch of longitudinal section; V = velocity of rubbing, in feet, per minute; d = diameter of journal in inches.

"In no case in general practice should the pressure, on even the slowest moving journals, be allowed to exceed 1,000 pounds per sq. inch of longitudinal section with steel journals, or about 600 on iron, running in well worn boxes in each case.

"Special care should always be taken to provide for effective lubrication."

Commercial Production of Hydrogen.—M. Tessié du Mothay, whose name is familiar to the readers of the "JOURNAL" as the inventor of a number of processes in manufacturing chemistry—prominent among which are those for producing oxygen and chlorine continuously—has recently published a method of producing hydrogen upon a large scale; the ultimate design of the inventor being the utilization of the gas as an illuminating agent after carburetting with light petroleum oil, or similar substances.

It consists, according to his description, in leading steam into a furnace of coke heated to redness. By this treatment, hydrogen and carbonic oxide are formed. From this mixture the carbonic oxide is removed by passing the gases through a series of cylinders filled with hydrated lime heated to redness. The result of this last process is the formation of a fresh equivalent of hydrogen and the conversion of the carbonic oxide into carbonic acid by union with the oxygen liberated from the water of hydration. The carbonic acid remains behind as lime carbonate, while the hydrogen is passed through or over

one of the light petroleum oils, by which it becomes carburetted, and is in this condition passed through tubes heated to a low red heat, whereby the gas and vapor are converted into a permanent gas—of high illuminating quality—and well adapted for lighting or for heating purposes.

Carbon from Gas.—It is reported, upon reliable authority, that a company has been established, and is now in operation, with the object of manufacturing lampblack from the escaping gas of an abandoned oil-well at or near Cumberland, Md.

The gas-flames are directed against soapstone plates, and upon these the deposit of soot is made, which is subsequently removed by suitable means and packed in tin boxes of convenient size for transportation. At present there are said to be 660 8-foot burners in operation. It is further stated that the company contemplate shortly increasing its operations by the erection of a larger building and the introduction of double the numbers.

This method of utilizing what would be otherwise simply a waste product is worthy of emulation, and is, we believe, a purely original idea with the projector of the enterprise, Mr. Horworth, of Boston.

Newly Discovered Tin Fields.—The importance attaching to the multiplication of the sources of obtaining tin, gives rise every now and then to sensational accounts of wonderful finds of ores of this metal. With some of these reported localities in our own country the readers of the "Journal" will be familiar. At length, however, the world is furnished with the statement that a tin field of unexampled richness has been discovered in the English colony of Queensland, and the statement is substantiated so fully that there can remain no reasonable ground to doubt the fact that the discoveries are both genuine and important. The reports state that the presence of tin has been detected over an area of 550 square miles, the richest source being the river gravels. It seems possible, therefore, that Eastern Australia may soon compete with Cornwall as a tin-producing country.

A New Experiment.—If fifteen to twenty grammes of granulated silver are introduced together with 30 to 40 grammes of bisulphide of carbon into a hard white glass tube, and hermetically sealed, then, upon gently warming and then shaking in the dark, sparks will be observed in the tube, which by continued shaking may be rendered quite luminous. Pouring water on the tube causes the luminosity to disappear, but, upon shaking, it re-appears again.

Bursting of a Fly-Wheel.*—An English contemporary contains an account of a disastrous accident of this kind which recently occurred at the Bolton Iron and Steel Works, which involved a loss of life and immense damage to property. The accident occurred in the rail mill, where some twenty persons are employed day and night. After the starting of the engine, the belt came off the governor-shaft, which caused the engine to run at a greatly accelerated speed, the consequence being that the fly-wheel, 26 feet in diameter, and weighing 60 tons, flew asunder with a loud report, the fragments of which, eight in number, were projected with destructive effect into the works. The roof of the mill was brought down, the boilers, rolls and machinery of the mill greatly damaged, while other fragments were projected beyond the building with equally destructive results. Nearly all the workmen in the mill at the time were more or less injured.

It is doubtful whether any case of this kind is upon record, which can equal this one in violence.

The "Devastation."—The contest between artillerists and naval architects has culminated in the production of the "Devastation," "Thunderer," and "Fury," protected by 12 inches of armor, and of 35-ton guns to perforate such plates at the distance of 1000 yards. The "Devastation," a ship of 9188 tons displacement, and 5600 indicated horse-power, is the first sea-going ship-of-war designed without sails. Carrying 1600 tons of coal, she is expected to run, at a 5-knot speed, about 9200 miles without replenishing her coal-bunkers. Her side armor of 12 inches is only penetrable to 25-ton guns when struck at right angles, within 200 or 300 yards' range. The 14-inch iron plates on the front of the turrets would be impenetrable to British 25-ton guns as at present rifled. The total weight of armor carried by the "Devastation" is twice as great as that which protects the turret-ship "Monarch," of 8322 tons, and is equal to more than three-quarters of the weight of the hull which carries it. This is the most advanced of the three mastless ships, each of which is intended to carry four 35-ton guns in two turrets, throwing at each discharge 2800 lbs. of iron with a striking force at their muzzles of 31,412 foot-tons. Enormous as is this offensive power, it hardly bears a due proportion to the defensive superiority of the "Devastation" over other sea-going ships. True, each gun would perforate armor which would be impenetrable to those of any other ships, but such as is not yet carried by

* Engineer, xxxv, 18.

foreign vessels. There are very few foreign iron-clads whose sides would not be equally penetrable to 18 and 25-ton guns, whilst the shell power of such guns is greatly superior to that of the 35-ton gun. In bombarding fortresses the sums of the squares of the bursting charges of the shells may be taken as the measure of offensive power. The "Devastation" could at each discharge explode only 80½ lbs. of powder within a fortress, but the "Monarch" would explode more than double that quantity, and the "Sultan," using only one broadside, would explode 60 lbs. more than the "Devastation." Adding together the squares of their bursters, the relative shell power of these ships on one broadside is—"Devastation," 1620; "Monarch," 5386; and "Sultan," 3404.—COMMANDER W. DAWSON, *in "Naval Science" for October.*

AMERICAN SOCIETY OF CIVIL ENGINEERS.

The following abstract of the proceedings of the Society came too late for insertion in its appropriate department:

A regular meeting of this Society was held at its rooms, in New York, January 8th.

A paper, by Charles B. Richards, M. E., of Hartford, Conn., recording "Experiments on the Resistance of Stones to Crushing," was read.

The specimens tested were old and dry samples, well selected, of various American building stones, worked into 1″ and 1½″ cubes, with flat and smooth faces.

The testing machine used was built after a long experience with two smaller and similar machines. It is arranged to weigh the strains upon a sensitive platform scale of 50 tons capacity, and is well adapted to quickly give accurate results.

The specimens were crushed between the plane faces of two hardened steel hemispheres, the curved portions of which were seated in corresponding cavities of steel blocks, fixed in the machine. Single thicknesses of "lace" leather were interposed between the stones and metal surfaces; thus the pressure was uniformly distributed; it was, in all cases, applied to the faces of the cubes, parallel to the natural bed of the stone, and carefully increased to rupture by pouring shot into the hollow weight by which the strain was caused.

Tables were presented, giving the minimum, mean, and maximum resistance to crushing per square inch of the specimens tested.

Sixteen specimens of granite, from six quarries, gave from 8620 to 15,622 pounds minimum, 9838 to 18,778 pounds maximum strength;* and ten specimens of *white marble*, from three quarries, gave from 3905 to 12,917 minimum, and 5976 and 13,972 pounds maximum strength—each being 1″ cubes.

The specimens failed by breaking up into slender prisms and pyramids, with axes normal to the pressure.

A brief paper, by F. Collingwood, C. E., of New York, upon "Rock Drilling," was also read.

In it was stated that a percussive steam-drill, with 3″ cylinder and 6″ stroke, making 300 to 375 strokes per minute, would drill in the coarse gneiss rock, common on New York Island, 1⅝″ holes 3″, 1⅜″ holes 4½″ and 1″ holes 5″ per minute.

Joseph P. Davis, C. E., of Boston, Mass., compared the late Chicago and Boston fires, and suggested a question for discussion, and one on which information is much needed, namely, "Fires and their Management; the Best Appliances and Methods for Putting them Out."

Upon motion of M. N. Forney, M. E., of New York, a committee, consisting of Messrs. Asabell Welch of Lambertville, N. J., John Griffin of Phœnixville, Pa., Max Hjortzberg of Chicago, Ill., and two others to be named by the Chairman, were appointed to make an investigation, by means of a circular of inquiry sent to each member of the Society, and by such other methods as the committee may choose to adopt, to determine the following points:

1. The best form for standard rail sections for the railroads of this country.
2. The proportion which the weight of rails should bear to the maximum loads carried on a single pair of wheels of locomotives or cars.
3. The best method of manufacturing and testing rails.
4. The endurance or, as it is called, the "life" of rails.
5. The causes of the breaking of rails while in use, and the most effective way of preventing it.

The Committee to report the results of their investigations at the next annual convention of the Society.

* Fourteen specimens of sandstone, from three quarries, gave from 5808 pounds minimum, and 8956 to 10923 pounds maximum strength.

Civil and Mechanical Engineering.

INTEROCEANIC COMMUNICATION.

By Prof. J. E. Nourse, U.S.N.

(Continued from Vol. LXIII, page 313.)

* The Nicaragua Route.

On apparently very strong grounds, this line for a ship canal has, at different times, enlisted the attention of many who were not mere adventurers or money-schemers. This last term is applied to all such parties as have exerted themselves sufficiently to revive an old idea on some one of these lines, in order chiefly to the organization of companies, so-called, or the sale of enough of stock to pay salaries and working expenses in breaking ground only, and then to the sale or forfeiture of an obtained concession. It is not to be disguised that, unfortunately for the interests of a true survey, there is such a record. And it cannot be too much insisted upon by those who look for final success, that such a survey will never be secured except under an organized party, who have ability enough to know and appreciate the whole work before them, having in their service persons of experience in dealing with the great difficulties in these tropical jungles, marshes and mountains.

More than one reported success, but true *failure*, can be traced back to a serious lack here.

The strongest claims for a final survey of the Nicaragua route for a transit suited to the wants of the age, are the water communication of the central lakes and their ability to feed the remaining line of the canal.

By the water communications hopefully to be established through the lakes and their outlets, the isthmus "may be reduced to about one-tenth of its whole breadth."

In the bodies of water within these lakes a reservoir or feeder exists such as is found on no other of the lines; their narrowness permits no such water supply. Secure, then, any new or improved harbor facilities, and a canalization of the outlets on this line, and the canal seems surely practicable.

Let us look at a few chapters in its history.

* This article, in a series nearly completed, has been designedly delayed until the facts furnished by the recent Government Expedition, and those in connection with a second, now preparing, could be available.

First Attempts by Great Britain.

Great Britain has made several unfortunate efforts to possess herself of the route for an inter-oceanic canal through Nicaragua. The first was in 1740, by the Superintendent of the Moschito Coast; this was disavowed by the Government.

Somewhat later a more noted effort was made. In 1780, Captain, afterward Lord Nelson, under orders from Admiral Sir Peter Parker, convoyed a force of 2000 men, under Col. Polson, with original instructions limiting his own responsibility to the convoy only. But Nelson (then at the age only of 22) found it necessary to take a more active part. His plan of operations reads thus: "In order to give facility to the *great object* of Government, I intend to possess the Lake of Nicaragua, which for the present may be looked upon as the inland Gibraltar of Spanish America. As it commands the only water pass between the oceans, its situation must ever render it a principal post to insure passage to the Southern Ocean, and by our possession of it Spanish America is severed into two."

The expedition reached San Juan March 24th, 1780, "in good health and spirits." Of the squadron, composed of two frigates, two brigs-of-war and a line-of-battle-ship, none would venture to cross the bar except Nelson's corvette. It was the end of the dry season. The passage of the San Juan was exceedingly difficult; for the seamen, although assisted by Indians from Blewtown, scarcely forced their loaded boats up the shoals, and their exposure to the sand-heats and night dews, without sufficient provisions,* or the possibility of hospital care, made fearful havoc with their health. Nelson leaped ashore with a few seamen, stormed the first Spanish battery, 16 miles below San Carlos, and took that fort itself on the 24th of the month. But although the capture was made (Nelson here "commencing his career of glory"), he himself and the few officers and men who survived barely escaped with their lives. "So general was the sickness that enough orderly men were not left to attend the sick." Out of eighteen hundred men scarce three hundred ever left Nicaragua. Of a crew of two hundred men, on the Hinchinbrook, eighty-seven took to their beds in one night. * * * The remnant returned to Jamaica in October. "Had the expedition," said Nelson, "arrived at San

* "At one time they were obliged to subsist chiefly on broth made by boiling the monkeys that were caught. Nelson never could touch this, after once seeing the monkeys in the cauldron."

Juan's harbor in January, the violent torrents would have subsided, and the whole force would not have had to get wet, while dragging their boats, three or four times each day."

Movements in Nicaragua in this Century.

After the establishment of independence in Central America, the first attempt towards opening the canal was made by Senor de la Cerda, afterwards Governor, who urged it upon the Federal Congress in the year 1823; but the succeeding disturbances deferred all movements until 1825, when the Congress passed a decree authorizing its opening. Proposals were made by Mr. Bayley, agent for Barclay & Co., and by Mr. Beniski, for Aaron Palmer & Co., of New York. The Nicaraguan Government, though aware of Mr. Bayley's character and experience, preferred to take an unconditional offer from Beniski, who promised to pay down $200,000, and open a canal. A scheme was announced as under the patronage of the President of the United States, and of eminent New York men, including De Witt Clinton. No capital was raised.

In 1828, the King of the Netherlands proposed to undertake the work, if a survey should show its practicability. The Dutch General Verveer came over with instructions to undertake the canal. He found Central America in the midst of one of her incessant revolutions; the matter was deferred; the liberal offers of the Dutch Government were not finally closed, and the revolutions in their own country (1830) put an end to the plans.

March 3d, 1835, a resolution passed the U. S. Senate that the President be requested to consider the expediency of opening negotiations with other governments, and particularly with Central America, for protecting individuals or companies who may undertake to open a communication between the Atlantic and Pacific Oceans. A special agent was appointed by Gen. Jackson—Mr. Charles Biddle, formerly of Philadelphia—to visit the different routes best adapted for interoceanic transit. He appears, however, to have visited only the line of the present Panama Railroad, and, after this visit and an attendance on the Congress at Bogota, where he received information on the different lines, he returned to the United States, regarding his success in the examination of the Panama line for the purpose of a railroad sufficient to warrant him in omitting further investigations. His instructions had been to proceed to San Juan and the Nicaragua Lake; but, from the difficulty of obtaining a conveyance to San Juan,

he had landed at Panama. Mr. Biddle died before reaching Washington to report upon his mission.

Bailey's Surveys.

In 1837, Gen. Morazan, President of Nicaragua, resolved to have accurate surveys made, intending to raise a loan in Europe. Mr. John Bailey, Lieut. of Marines, H. P., for 20 years resident in Nicaragua, was employed for this purpose. His results were communicated to the Royal Geographical Society in 1844, but only partially published.

It appears that in 1837–38, he "surveyed the Lake of Grenada (Nicaragua), the River San Juan, flowing out of it at the port of San Juan del Norte, lat. 10° 56′ 45″ N., long. 83° 43′ 14″ W., and the isthmus between the lake and San Juan del Sur, lat. 11° 15′ 37″ N., long. 85° 52′ 56″ W."

His proposed line, as given in the Society's Journal, and afterwards in his own work, published in 1850, was the course of the San Juan del Norte, thence by the Lake Nicaragua, terminating in the coast at San Juan del Sur. Between that port and the mouth of the Lajas River, emptying into Lake Nicaragua, a line of levels—"a series of 351 levels"—was taken in 1838, at different stations.

	Feet.
From these levels he made the sum of the ascents, . .	1047
The sum of the descents, ...	919
Hence the difference or height of Lake Nicaragua above the Pacific Ocean, at low water, is	128

This result has a near approximation to that quoted by Thompson in his "Guatemala," as obtained from a series of 347 water levels, at an average distance of 100 yards each, made by order of the Captain General Galvez, the excess of descents then ascertained being 133 feet.

It was considered unfortunate by some that Bailey's survey was not carried on the line passing through the Lakes Managua to the port Realejo. On the other hand, Capt. Belcher, R. N., in 1837, found it necessary to correct the accounts which represented Realejo as a harbor. He says: "Trusting to the accounts I had read of the magnificence of this port, I had fully intended placing the 'Sulphur' (380 tons) near the town. The visit of the captain of the port soon undeceived me. He assured me that, at low water, not more than three

feet would be found near the town, and so narrow that there was barely room for the oars of my gig. * * The distance from the position where vessels usually anchor (Cardon) to Realejo is a sad drawback." Cardon, *nine miles* from Realejo, has two entrances, both of which are safe under proper precaution.

Mr. Bailey doubtless did an arduous and faithful work for more than two years on this survey. By the dissolution of the Federal Government, and the repudiation of its debts by each State, he seems to have utterly failed of reward.

The surveys by Bailey had revived the plans of Galisteo (1781), and popularized in Nicaragua the idea of a canal. From 1838, therefore, to 1846, movements for it were set on foot with Belgium, and with Louis Napoleon while a prisoner in the fortress of Ham. M. Castellon (afterward slain during Walker's invasion) was sent in 1844, by Guatemala, San Salvador and Honduras, to solicit the protection of France, and in return to offer the commercial advantages of the country. M. Guizot was at that time already committed to a full examination of the *Panama* route, given into Garella's charge during the previous year,—a route, too, where no conflict with British interests was involved. Castellon, however, received permission to visit Louis Napoleon. He succeeded in impressing him with the idea of the work in Nicaragua with sufficient favor to obtain from the Prince the decision that, if he should recover his liberty, he would proceed to America and undertake the canal. A decree in 1846 assigned to the enterprise the name "Canale Napoleone de Nicaragua." But the captive was not allowed to go over; the destinies of France were to be in his hands; the influence he had always coveted to wield for the Latin race and for France in the western world was never to be wielded. After Napoleon's arrival in London, he earnestly advocated before the Institution of Civil Engineers the superior advantages of this route. In a pamphlet, with the initials L. N. B., and more fully in "Les Œuvres de Napoleon," Vol. II, a route terminating on the Pacific at Realejo, and the plans of development for Central America, were drawn out. In order to secure this end, he advocates a line not to cut through the narrowest tongue of land, but through the country most populous, fertile, healthy, and crossed by the greatest number of rivers. "There are some countries," says the Prince, "which, by their geographical position, are destined to the highest rank in prosperity, provided that, where nature has done everything for man, he does not neglect to make use of the advantage placed in his hands.

Tyre, Carthage, Constantinople, Venice, London; and, in the new world, Leon or Massaya—as favorably situated as Constantinople in the old—are noted examples of what prosperity may be attained by places situated like these for commerce."

M. Felix Belly himself, afterward so closely connected with the Nicaraguan plans, says of the Prince's ideas, at this time, that they were a reviving of the old dreams of attaining the wealth of the East. "The Eastern vision of Constantinople and the Indies had been destroyed by the guns of Sydney Smith at St. Jean d'Acre; this new Western vision before Napoleon borrowed intensity every day from the ennui of a five years' confinement." The vision, however, early sank out of view in the West. The pamphlet, "L. N. B.," and the detailed route, estimated cost and revenues of the "Canale Napoleone" in his works, are all which remain.

Political and commercial events came on of higher moment than the attempted transfer even of a Napoleon to our hemisphere. The gold fields of California, in 1849, opened up the great change. Their discovery, by creating necessities for the transportation of the multitudes whom they seemed to invite, stirred again direct propositions to the Government of Nicaragua. Mr. Wheelwright, the projector of a British line of steamers on the west coast of South America, with some American citizens alive to the enterprise, asked a concession. In the meantime England, reviving the ideas of Nelson's day, bent its whole policy in Central America to acquiring permanent control of the isthmus. In January, 1848, she siezed the port of San Juan, naming it—in honor of Lord Grey, then Governor of Jamaica, and as the terminus of a canal—*Greytown*. The British Vice-Consul Manning wrote Lord Palmerston, earnestly urging a British Protectorate, in order to "obtain control of so desirable a spot in the commercial world, and to free it from the competition of so adventurous a race as the North Americans."

As the final result of representations against these English movements, made in 1847—48 to the President of the United States by the Supreme Director and by the Secretary of State of Nicaragua, Mr. Hise, and afterward Mr. E. G. Squier, were sent on missions chiefly in regard to the transit. Messrs. Vanderbilt and White, being at the same time applicants before the Government of Nicaragua for a canal charter, succeeded in obtaining a liberal concession for the "American Atlantic and Pacific Ship Canal Company," the American Chargé having given to the grantors assurance that his govern-

ment would extend its guarantees to a proper charter. The treaty stipulations made in connection with this grant were ratified unanimously by Nicaragua, but gave way in the United States to the famous Clayton-Bulwer Treaty, which was believed by the American Secretary of State to secure unequivocally "the liberation of Central America from the dominion of any foreign power."

The Company organized in New York for the construction of a canal, sent out Col. O. W. Childs, a distinguished engineer of Philadelphia, to make a full survey. As exhibiting the entire confidence held by the projectors in the enterprise, a public banquet was given by them February 12th, 1850, before even a reconnoissance had been made. In January, 1851, the successful passage of the San Juan and navigation by a steamer on the Lake Nicaragua, was hailed with enthusiasm. The movement itself, in connection with the increase of adventurers to California, largely influenced emigration and purchase in Nicaragua, lands advancing in price in the projected town of "Corinth," on the Bay of Realejo, from four francs to one hundred and twenty-five per hectare.

But although a wondrous activity in trade was temporarily aroused in Nicaragua, and there seemed every promise one could desire for that country as a token of what true benefits would accrue if the canal were opened, three things forcibly arrested its best prospects. These were the disfavor shown by capitalists in England to the report of Col. Childs; the fact that greater gains by far were to be realized by using this route as a mere passenger transit than by going on with a canal project; and, lastly, the miserable invasion of the country by Walker's Buccaneers. The report of Col. Childs estimated for a canal of but 17 feet in depth and 50 feet in width (nearly 10 feet less in depth and nearly 200 feet less in width than the Suez Ship Canal), at a cost of $31,500,000. The report, as well as the survey itself, was a work of the highest character, trustworthy and safe. But the English capitalists shrank from an investment in an enterprise the report of which, though conforming to the requirements of modern engineering, admitted that an increase in cost would by no means be proportionated to the increased dimensions required for the commerce of the age. The original charter to the American Atlantic and Pacific Ship Canal Company, was permitted by the Nicaragua Government to have its ship canal powers and privileges *reserved* and separated, and a new company, "The Accessory Transit Company," was formed under its franchise. The profits of travel and traffic under

this minor arrangement, carried the larger original enterprise out of view; and the invasion and misrule of Walker closed off public attention.

The conflict between the Company and the buccaneer brought on the destruction of Greytown, and left an evil feeling against Americans in place of the advanced good feeling which had prevailed. It seriously injured the transit of passengers. Yet, between 1851 and 1867—a date later than belongs to the thread of our narrative at this point—the large number of 150,000 passengers were conveyed across this route. It was an opposition line to the Panama Railroad.

Two eras in the history of the route remain to be noticed:

I. The first is the outlay by the "Central American Transit Company" in their projected improvement of the harbor of Greytown. In 1865, Capt. Preston C. F. West, of U. S. Coast Survey, was appointed to make surveys which would "determine the practicability of improving the San Juan River, and of reclaiming the harbor of Greytown. His appointment was the result of an application from Don L. Molina, Minister from Nicaragua to the United States, and in conformity with an article in the contract between the Nicaraguan Government and the Company. Capt. West's report was unwillingly but decidedly unfavorable. In respect of Greytown, especially, he reported: "After carefully studying the question of improvement to admit ocean steamships, I am sorry to be obliged to recommend the abandonment of the idea." The whole report was, however, submitted by the disappointed parties to a Commission asked for by the Secretary of State (on the application of the Nicaraguan Minister) from the National Academy of Sciences. This Board, consisting of General Humphreys, U. S. A., Admiral Davis, U. S. N., and Messrs. Hilgard and Mitchell, of the Coast Survey, confirmed in the main the judgments expressed by Capt. West. The outlay by the Company of a large amount in spite of these unfavorable auspices, was almost an unmodified loss.

II. The consolidation of the interests of the original Atlantic and Pacific Steamship Canal Company, the Accessory Transit Company and the Central American Transit Company into the one Company last named, awakens a new financial and commercial interest in the route, and has led to an expedition for further surveys authorized by the Navy Department, under an Act of Congress of 1871.

An expedition, under command of A. F. Crosman, U. S. N., of Philadelphia, left the United States in the Spring of 1872. The

season was too far advanced toward the beginning of the tropical rains to permit more than a mere reconnoissance for a proper survey in the Fall. Com. Crosman's instructions contemplated an examination of Limon Bay on the south and Monkey point on the north, as a substitute, if possible in either case, for the lost harbor of Greytown; also, the running of a line of levels on some new and more promising route from Lake Nicaragua to the Pacific.

Having but just landed a party of observation at Port Limon, and arranged for landing and beginning full work by ascending the Colorado river, most unhappily the commander was drowned, together with Master Foree, U. S. N., and four men, off the bar at Greytown, April 7th, 1872.

Com. Hatfield, U. S. N., assuming the charge of the expedition, ascended the Colorado, and, from its junction, the San Juan also, to Fort San Carlos, experiencing the same difficulties in kind in getting his steam launch up the rapids, as Nelson in his day found with his boats. In nine days, however, he placed the launch on the great lake, provided for its employ in taking the soundings necessary upon it, and, proceeding to La Virgin, organized parties for surveys from the mouths of the Sapoa and the Lajas. The line from the lake to Salinas Bay by the river Sapoa proved entirely impracticable, by reason of the altitude of the summit level. One of Col. Child's original lines was examined with more favorable results than offered by him. A new line, including part of this and measuring, it is believed, but sixteen miles from the Lake, was begun. It will be the first resumed by the party organizing at the date of this communication, under Commander E. P. Lull, U. S. N., who was selected by the Navy Department to pursue these investigations immediately on the report of Commander Crossman's death. Another line was begun by Commander Hatfield, by the River Ochomaga; sufficient time, however—only five weeks of work in all—could not be given by Hatfield's expedition to secure any full basis of decision on the routes. His faithful labors were commended by the Government.

There is this encouraging fact to those who have hope of the Nicaragua route, as probably the last hope of securing early a ship canal on this Continent, that both Col. Childs and several of his assistants in the survey of 1851–52, including Mr. Sweet and Mr. Cropsey, of the New York Engineers, have confidently believed that a practicable route can and will here be found.

The Navy Department now sends there an able and experienced of-

ficer, previously on the isthmus explorations; he will accomplish what can be done in securing that which the now assured success of the Suez Canal more than ever demands for American commerce and our American name.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from Vol. LXIV, page 344.)

Frictional Gearing.—"Frictional Gearing is a term applied by Webster to wheels that transmit motion by surface contact without teeth. This style of gearing is much used in the lumbering region of the 'north west,' and is fast gaining favor wherever applied. It has some advantages, not possessed by other modes of communicating motion, which do not appear to be counteracted by any peculiar disadvantages.

"In large mills where this gearing is used to transmit power to drive five or six gangs, one or two large circular saws, a muley, gang edgers, trimmers, slashers, lath mills, shingle mills and other machinery, where 20,000 feet of boards may be sawn in an hour, the faces of the wheels are made as smooth and straight as possible; one wheel is made of iron and the other of wood, or of iron covered with wood.

"Where it is practicable, this gearing is so arranged that the wood drives the iron, to prevent the 'slip' at starting from wearing the wood-faced wheel unevenly. Although this tendency is much less than might be supposed, as in most cases the 'bull-wheel,' used for drawing logs into the mill, is a large wooden wheel driven by a small one of iron, and these wheels, started and stopped while the driver is in full motion a hundred times a day, work well and last for several years. But for machinery in constant use, the wooden wheel should always drive the iron wheel.

"For driving heavy machinery, the wooden drivers are put upon the engine shaft, and each machine is driven by a separate counter-shaft. Two or more of these counter-shafts are usually driven by contact with the same wheel, and each is arranged so as to be thrown out from the driver and stopped whenever required, and again started at any moment, by a slight movement, without interference with other machinery.

"To drive small machinery, these friction drivers are put upon a line shaft so as to drive a small counter-shaft, from which the machine is driven by a belt, which may be shifted in the usual way.

"In many mills from 100 to 300 horse power are transmitted by this kind of gearing.

"For driving light machinery, running at high speed, as in sash, door and blind factories, basswood—the linden of the Southern and Middle States—has been found to possess good qualities, having considerable durability and being unsurpassed in the smoothness and softness of its movement. Cotton-wood has been tried for small machinery, with results somewhat similar to those of basswood, but is found to be more affected by atmospheric changes; even white pine makes a driving surface which is, considering the softness of the wood, of astonishing efficiency and durability. But for all heavy work, where from 20 to 60 horse power is transmitted by a single contact, soft maple has, at present, no rival. Driving pulleys of this wood, if correctly proportioned and well built, will run for years with no perceptible wear. For very small pulleys, leather is an excellent driver, and very durable.

"Recently paper has been introduced as a driver for small machinery, and has been applied in some situations where the test was most severe; and the remarkable manner in which it has thus far withstood the severity of these tests, appears to point to it as the most efficient material yet tried.

"The proportioning of friction pulleys to the work required, and their substantial and accurate construction, are matters of perhaps more importance than the selection of material. The mechanic who thinks he can put up frictional gearing temporarily and cheaply will make it a failure. Leather belts may be made to submit to all manner of abuse, but it is not so with friction pulleys. They must be accurately and substantially made, and put up and kept in perfect line.

"All large drivers, say from 4 to 10 feet diameter, and from 12 to 30 inch face, should have rims of soft maple 6 or 7 inches deep. These should be made up of plank, $1\frac{1}{2}$ or 2 inches thick, cut into 'cants,' $\frac{1}{6}$, $\frac{1}{8}$, or $\frac{1}{10}$ of a circle, so as to place the grain of the wood as nearly as practicable in the direction of the circumference. The cants should be closely fitted, and be put together with white lead or glue, strongly nailed and bolted. The wooden rim thus made up to within about 3 inches of the width required for the finished pulley, is mounted upon one or two heavy iron 'spiders,' with 6 or 8 radial arms. It the pulley is above 6 feet in diameter, there should be 8 arms, and 2 spiders when the width of face is more than 18 inches.

"Upon the ends of the arms are flat 'pads,' which should be of

just sufficient width to extend across the inner face of the wooden rim, as described, that is, 3 inches less than the width of the finished pulley. These pads are gained into the inner side of the rim, the gains being cut large enough to admit keys under and beside the pads. When the keys are well driven, strong 'lag' screws are put through the ends of the arm into the rim. This done, an additional 'round' is put upon each side of the rim to cover bolt heads and secure the keys from ever working out. The pulley is now put to its place on the shaft and keyed, the edges trued up, and the face turned off with the utmost exactness.

"For small drivers, the best construction is to make an iron pulley of about 8 inches less diameter and 3 inches less face than the pulley required. Have 4 lugs about one inch square cast across the face of this pulley. Make a wooden rim, 4 inches deep, with face equal to that of the iron pulley, and the inside diameter equal to the outer diameter of the iron. Drive this rim snugly on over the rim of the iron pulley, having cut gains to receive the lugs, together with a hard wood key beside each. Now add a round of cants upon each side, with their diameter less than the first, so as to cover the iron rim. If the pulley is designed for heavy work, the wood should be maple, and should be well fastened by lag screws put through the iron rim. But for light work, it may be of basswood or pine, and the lag screws omitted. But in all cases the wood should be thoroughly seasoned.

"In the early use of friction gearing, when it was used only as backing gear in saw-mills, and for hoisting in grist-mills, the pulleys were made so as to present the end of the wood to the surface; and we occasionally yet meet with an instance where they are so made. But such pulleys never run so smoothly nor drive so well as those made with the fibre more nearly in line with the work. Besides, it is much more difficult to make up a pulley with the grain placed radially, and to secure it so that the blocks will not split when put to heavy work, than it is to make it up as above described.

"As to the width of face required in frictional gearing, when the drivers are of maple, a width of face equal to that required for a good single leather belt to do the same work, is sufficient. Or, to speak more definitely, when the travel of the surface is equal to 1200 feet per minute, the width of face should be at least one inch for each horse-power to be transmitted, and for drivers of bass wood or pine, 1½ to 2 inches.

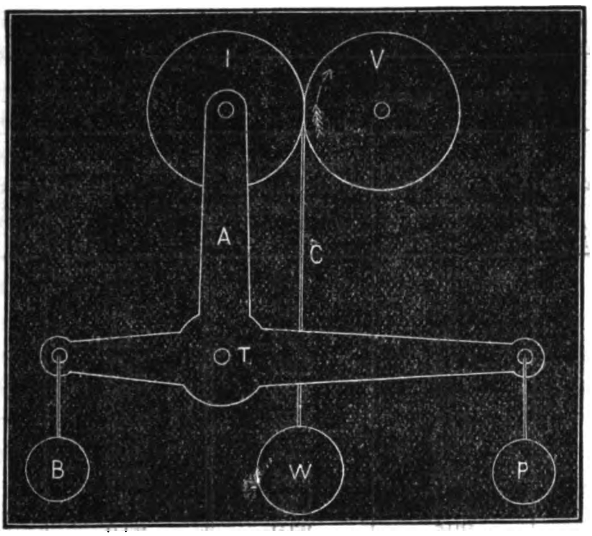
"The driven pulleys are wholly of iron, and similar to belt pulleys,

but much heavier, having more arms and stronger rim. The arms should be straight rather than curved, and there should be two sets of arms when the face of the pulley is above 16 inches. A very good rule is to make the thickness of the rim $2\frac{1}{2}$ per cent. of the diameter of the pulley.

"To secure perfect accuracy, these pulleys must be fitted and turned upon the shaft; and when large, the shaft should run in journal boxes, while the face is being turned, after which they should be balanced, neglect of which has been the means of destroying friction pulleys that otherwise were well made."

"The conditions and results of a few experiments, made to test the tractive power of smooth faced friction pulleys, are here given. These experiments, when made, were not meant for publication or for the benefit of science, but to establish rules for private practice. They should be repeated by others before being taken as conclusive.

"For the experiments, two pulleys were made in the usual way, one being of wood—soft maple—and the other of iron. Both were accurately and smoothly finished. These pulleys were each 17 inches in diameter, and of 6 inch face, and were put up as shown in the annexed diagram:



"A is a double bell crank frame, with arms 2 feet long. The ends of the upright arms receive the bearings for the iron pulley, I. The journals of this pulley are $1\frac{1}{2}$ inches diameter and 8 inches long, and run in Babbitt boxes. The frame is hung upon journals, T, and is

balanced by the weight, B. The face of the pulley, I, is extended beyond the six inches to receive the cord, C, for which purpose a shallow groove is cut in the pulley, so as to bring the centre of the cord to the periphery. The driving pulley, V, is put upon a shaft where it may be made to revolve slowly in the direction of the arrow.

"It will be seen that P will bring the pulleys together with a pressure just equal to its weight. The wooden pulley being in motion, the pressure, when sufficient, will roll the other pulley and raise the weight, W.

"The manner of experimenting was to put a given weight upon the cord, C, and while the driving pulley was moving, to increase the weight, P, until W was lifted. The machinery was then stopped, when the weight would descend, slipping the iron pulley upon the wood. The weight of P was now noted; the weight was again raised, and the pressure increased sufficiently to hold the weight from slipping down, and the pressure again noted.

"After these experiments were made and twice repeated with the pulleys, the frame, A, was reversed, so that the weight, P, would tend to separate the pulleys. They were then connected by a 6-inch leather belt, and the experiments repeated, giving the results in the fourth and fifth columns.

Friction Pulleys.			Belted Pulleys.	
Weight raised.	Pressure required to just raise the weight.	Pressure required to raise the weight without slip.	Pressure required to raise the weight.	Pressure required to raise the weight without slip.
10	29	53	30	34
20	58	65	60	69
30	87	96	91	120
40	115	125	121	159
50	143	154	153	199
60	171	185	183	242
70	199	214	213	247
80	225	244	239	332
90	264	289	278	375
100	295	312	310	419
120	354	387	372	487
140	416	438	442	563
160	477	499	524	652
180	538	561	592	731

"It will be seen that, in this test, the traction of the friction wheels was greater than that of the belted pulleys, and considerably more than is usually supposed to be obtained from belts upon pulleys of either wood or iron; and that while there is a marked falling off in the adhesion of the belt as the work increased, that of the friction increases as the labor becomes greater. Also that the difference in the pressure required to just do the work, and that necessary to do it without loss or slip, advances in an increasing ratio with the work of the belt; but in the friction it is almost constant throughout the whole range of experiments. The figures applied to the friction wheels are the mean results of repeated experiments; those applied to the belted pulleys are each of a single test. It is not thought that these experiments were sufficient to fully establish all that the figures show; but they were enough to prove that smooth faced wheels possess a much higher tractive power than has been generally supposed.

"And now a word as to some of the advantages of friction gearing. Being always arranged with a movable shaft, so that the wheels may be thrown together or apart with the greatest ease, the machine driven by it is started and stopped at any moment, while the driving wheel remains in motion. And when stopped, the separation is complete, and may so remain for any number of minutes or months without attention, and may be again started at any moment without the least inconvenience or injury. So slight is the separation required, that it is done almost without an effort. And by it we entirely dispense with the nuisance of loose pulleys, belt shifters and idle running belts, and with the risk of throwing off and putting on belts. It obviates the delay and labor of shipping and unshipping pinions, and the rattle and bang and frequent breaking of clutches. It is durable and requires no repairs; it is compact and economizes room. It does not increase the pressure on journals when the speed is quickened, as is the case with belts running with great velocity, but remains constant at all speeds. And it will transmit any amount of power, even up to 100 horse power, with no greater percentage of loss, and with less pressure on journals than can be done by belts.

"It is not intended that this style of gearing should supersede the belt. There are hundreds of situations in which nothing can take the place of belts. The ease with which they can be carried almost in any direction, and to any reasonable distance, will perhaps always place them foremost as a means of transmitting power. But where several machines, that must be run independently of each other, and

be stopped and started without interference, are driven by the same motor, one connection at least should be frictional, and that, if practicable, should be the connection nearest the motor. Where the motions are slow and the occasions for stopping few, this is of less importance; but where the speed is considerable and the stoppages are frequent, it will be found a very great convenience.

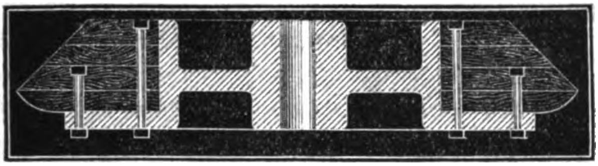
"Since the introduction of friction as a means of transmitting motion, it has often been desirable to apply the principle to bevel gearing. When correctly and substantially built and accurately put up, bevel and mitre friction wheels, within certain limits, operate just as well as those having cylindrical faces. In all fast motions, where not more than 10 horse-power are to be transmitted, the bevel friction is one of the best means of connecting at an angle. It may be adapted to almost any angle and change of speed. When required to give two motions in opposite directions, two equal bevel wheels facing each other may be secured to one shaft, and the third wheel matching, but not touching, yet placed on the end of a shaft, such that it may be brought into facial contact with either at pleasure.

"In building this gearing, the iron cone is made similar to a bevel pinion, but with a smoothly turned face, carefully finished and balanced.

"If not over 2½ feet in diameter, the driver may be built upon a 'hub flange'—a disc of iron of about two-thirds the diameter of the pulley, with a hub projecting from one side. The hub should extend one-half inch beyond the thickness of the wood to receive an annular disc of smaller diameter, through which the whole may be securely bolted together.

"Upon the flange, around the hub, the pulley should be built. The first two or three inches, to form the back, should be of hard wood, put on radially; for the other parts use soft maple, with the grain running as near tangentially as possible. The layers should be secured closely together with glue or white lead, and carefully and thoroughly nailed; after which the inner flange should be put on and the whole bolted together, and then truly turned to the exact angle and balanced.

"For a larger bevel driver it is best to use an iron center, with arms and a flanged rim of less diameter than the face of the wheel, to give room for the wood segments, thus:



"Upon this wheel the wooden rim is built as directed for the hub flange, except that the bolts must be put in as the work progresses, so that subsequent layers will cover the heads, and is finished without the smaller flange.

"In setting up this gearing it is of the utmost importance that the counter-shafts line exactly to the centers of the main shafts, and at the precise angle for which the pulleys were fitted, and that they are substantially set, so as not to get displaced.

"This gearing is thrown 'on' and 'off' by moving the counter shafts endwise in their bearings, This may be done by allowing the end of the shaft to extend through beyond the outer bearing far enough to receive an extra box, one end of which is closed and Babbitted to receive the end pressure. This box is set up by a lever to which it is pivoted. A groove in the end of the shaft where it is embraced by this box will serve to draw it back when the lever is released. In light work, it is as well to make the outer bearing answer for both end and side bearing, which may be moved in a line with the shaft.

"The pressure required to hold these pulleys up to the work is not great, and is easily applied by finishing the end of the shaft, and using a flat bearing of anti-friction metal, the full size of the shaft. Sometimes a steel point, like a lathe-center, is set against the end of the shaft to receive the pressure, but this is a very bad arrangement. It makes the bearing surface too small, and is one of the worst forms of bearing to keep supplied with oil. A flat bearing of wood, especially of hard maple, is very much better than this.

"When there is considerable difference in the sizes of bevel wheels working together, the end pressure is most upon the shaft carrying the larger; but this may frequently be neutralized, upon lines having several of these drivers, by setting them with their faces reversed.

"Facility of lever adjustment should always be provided."—E. S. Wicklin, *in Sci. Amer., April,* 1872.

ON THE FRANCIS DYNANOMETER.

A Paper read before the Franklin Institute at the Stated Meeting, December 18th, 1872, By Samuel Webber.

Gentlemen of the Franklin Institute:

Through the kindness of your President, I have the pleasure this evening of exhibiting to you an instrument for the measurement of power consumed by manufacturing machines and tools, commonly known as the "Francis Dynanometer."

The original of this machine was invented somewhere about the years 1836—7, by Mr. Samuel Batchelder, then agent and since Treasurer of the York Manufacturing Company at Saco, Maine, now living at Cambridge, Mass., one of the oldest living American cotton manufacturers, and differed from the present machine in delivering the power directly from the opposite end of the shaft to that on which the power was received.

As this mode of delivering not only reversed the direction of the power, but made it necessary to move the driving pulleys or the machine to make the connection, the second parallel shaft was added by James B. Francis, Esq., the agent and engineer of the Locks and Canals Co., at Lowell, thus restoring the direction of the transmitted power to the same line in which it was received, and making it practicable at once to place the dynanometer on the mill floor in the line of motion, and obtain readily the power required for any purpose.

The "dash-pot," or oil cylinder and piston, was also added to neutralize all jar and vibration, by preventing any sudden motion of the steel-yard, while the play of the piston in the cylinder is sufficient to admit of a slow motion with entire freedom.

The principle of the dynanometer is this: that of obtaining the "horse-power," or weight moved one foot per second, by suspending that weight to the end of a steelyard, which, were it not thus confined, would be free to rotate, and which would describe a circle of which its length is the radius.

The first shaft, passed directly through the axis of the steelyard, has fast on it, at one end, the driven pulley and a bevel gear, which forms one side of a compound or box gear.

The bevel on the opposite side and the delivering gear (which takes the place of the delivering pulley on the original machine) are fast on a sleeve or collar, which is caused to revolve in an opposite direction to the shaft by the two intermediate bevels, which complete the

compound, and which, being driven by the first gear, rotate freely around the steelyard, when no power is being transmitted, with the exception of such action as is due to the friction of the shaft and gears, which friction is ascertained and deducted in making a test of power.

The weight used on the original machine was 1 pound, and the length of the steelyard such (1·5919 ft., or 19 inches and a fraction) as to move the weight at its extremity 10 feet in one revolution, or 1,000 ft. in 100 revolutions; therefore 1 lb. moving 1000 ft. represented 1,000 lbs. moved 1 foot.

The present dynanometer, which you see was constructed by Hon. E. A. Straw, the Agent of the Amoskeag Company, at Manchester, N. H., and the present Governor of that State, on the same principle but by a different calculation; the two machines giving the same result in actual operation.

In this one, the steelyard is made the base of calculation, and is graduated in inches and tenths, each inch representing 100 lbs.

Starting at $6\frac{1}{2}$ inches from the centre to clear the frame, the graduation is carried out 20 inches, or to 2,000 lbs., and the weight obtained as follows: The extreme length is now $26\frac{1}{2}$ inches, thus being the radius of a circle of 53 inches diameter, or 166·504 inches circumference. This is 13·8753 feet described in one revolution, and the weight, to correspond to 1 pound moved 10 feet, is found to be ·7207 pounds.

Now this weight is only one-half of that required, for on the steelyard the action is that of supporting a weight supported at one end, and the weight is therefore doubled, making it 1·4414 lbs., or 1 lb. $7\frac{1}{16}$ oz. to represent 1,000 lbs. raised one foot in a second.

The poise or slide weight is obtained by a different calculation, as it is to represent 100 lbs. for every inch it is moved, and as a circle of 1 inch radius is 6·2832 inches in circumference, 100 times that circle is 628·32 inches, or 52·36 feet, and the weight to correspond with 1 lb. moved 100 feet, or 100 lbs. moved 1 ft. is found to be 1·9098 lbs., which, being doubled as before, gives 3·8197 lbs., or 3 lbs. $13\frac{3}{32}$ oz. nearly for the movable weight.

So much for the weights. The other element in the calculation is the velocity, which is obtained as follows:

A worm gear on the second shaft drives the clock by a pinion of one hundred teeth, and at every 100 revolutions rings a bell—the time of ringing being carefully noted by the observer—for such a pe-

riod as will enable him to fix accurately the time consumed in making 100 revolutions, whether it be 6 seconds, 13½, 19½, 27, or whatever it may be.

The practical operation of the dynanometer is this: having carefully levelled it and secured it to the floor in the proper line of motion, a belt is brought from the driving pulley on the shaft to the first pulley on the dynanometer, and one led from the second pulley on the dynanometer to the main pulley of the machine to be weighed, and the whole put in motion. The action of the bevel gears immediately raises the steelyard, which is then weighted till it remains motionless in a horizontal position. This weight is noted, and also the number of seconds consumed in making 100 revolutions. The belt leading to the machine is then thrown off, and the weight required to balance the dynanometer in motion also noted and deducted from the total weight. The weight thus obtained is divided by the number of seconds consumed, and the result is the number of pounds raised 1 ft. in 1 second.

For instance, the following is the transcript of a test I have recently made.

A 9 in. circular saw, cutting inch board.

Saw, 4,000 revs. per minute.

Dynanometer, 100 revs. in 14 seconds.

Gross weight,	13,000 lbs.
Less bal. dynanometer,	400 "
Net weight,	12,600 "

12,600 lbs. divided by 14, gives 900 lbs. moved 1 ft. per second.

900 pounds divided by 550 lbs. gives 1·637 horse-power.

550 lbs. moved 1 ft. per second being the same as 33,000 lbs. moved 1 ft. per minute.

Mr. Francis has used the dynanometer in Lowell for many years, and copies of his machine are used at Dover, N. H., Clinton, Mass., and some other places in New England; and other dynanometers have been constructed on various plans, with springs and levers, but none which seem to be at once so accurate and easy of application.

With the increase of manufacturing and the decrease of water power in New England, a great interest has arisen to know the exact economical value of various machines and the results of improvements in them, and it is to make a test of one of these improvements, invented by one of your townsmen, that I have brought this dynanometer to Philadelphia.

The result may be briefly tabulated as follows, showing the power required for cotton spinning at various speeds, on $30 yarn.

Best Ordinary Ring Frame.			Garseds & Jenks' New Spindle.	
No. Rev. Sp.	Pounds per Sp.	Sp. per H. P.	Pounds per Sp.	Sp. per H. P.
5,000	5	110	2·65	205
6,000	6·30	87·30	3·45	159
7,000	8·80	62·50	4·55	121
8,000			5·75	96
9,000			7·23	76
10,000			8·00	64

Driving a spindle and a half more per horse-power at 10,000 revolutions than the old frame drove at 7,000.

The following tests, from my memoranda, will also show its application:

	Horse Power.
194 ft. 2½ shafting, 216 revs. per min., weight, with pulleys, 5·415 lbs., continuous oiling, ...	·687
186 ft. 2⅛ shafting, 211 revs., 5,335 lbs., tallow and oil, .	1·442
Duplicate to the last, recently oiled, ...	1·234
9-inch circular saw above quoted, 4,000 revs, *pine*, . .	1.637
18-inch " " " 1·300 " *ash*, . .	1·273
1 small engine lathe, on 1 inch iron, heavy chip, . . .	0·212
1 " " ⅝ " light " . . .	0·092
1 cloth shear, 3 blades and fan, 2,000 revs., . . .	3·000
1 " 5 " " " . . .	4·136
First shaft noted above, driving 20 looms on heavy ticking, additional for looms, ...	3·855
Or 5·18 looms per horse-power.	
10 looms on 36-inch sheetings, ...	1·084
Or 9·23 looms per horse-power.	

This machine was designed to test the power of any machine ordinarily used in a cotton mill, and I have obtained results with it covering the ground between 8-horse power and $\frac{92}{1000}$ of one.

It has been carefully verified by a long series of tests with a "Prony Brake," applied to a friction pulley 1 foot in diameter, substituted for the present driver, and found to register accurately the added weight, plus a small and uniform allowance for friction, which I assume to

correspond very nearly to the friction added to the shaft of a mill, when the belt is put on which carries the machine; at all events, nearly enough so to make the added measurements in detail correspond very closely with the gross result as obtained from the indicator of an engine or the calculated power of a water wheel of the best construction.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

A regular meeting of this Society was held at its rooms, in New York, on Wednesday afternoon, December 4th.

A paper upon "Rail Economy," by C. P. Sandberg, C. E., of London, in which—under the three heads, Iron Rails, Steel Rails, and Traffic Capacity—the author deals with the saving that may be effected in the item of railway cost.

Iron Rails.—The American demand for English rails of say 500,000 tons yearly, is unlikely to diminish soon. The late increased expense of iron adds to the cost of railroad construction, and tends to reduce the quality of rails. Welsh rails were often imperfect in weld; now they are sometimes also brittle. In the Cleveland district rail-making has greatly improved, chiefly by the increased application of fettling in the puddling furnace.

Still the buyers must guard against lamination and brittleness by tests for strength and wear, applied before the rails are laid.

Rails made of suitable iron, with a proper section, will not break in winter. In Scandinavia, with a climate more severe than in America, no accident has occurred from broken rails, though cross sleepers are exclusively used. But a very small portion of the iron rails shipped to America will stand the proper tests.

No late improvement promises so much to perfect iron rail-making as mechanical puddling, which now seems to be an entire success. Among the best appliances for this purpose are those of Danks and Spencer; one producing the whole charge in one ball, and the other in several small ones. By this improvement more rails can be made, at a reduced cost and of better quality.

Steel Rails.—The demand during the past year has been so great for steel rails that they can hardly be obtained at any price. The supply is limited by the lack of ore free from sulphur and phosphorus, and recourse has been had to extensive mines in Spain. It is

hoped that America will supply herself with steel rails, and import only those of iron required for new lines or light traffic. There is a scarcity of suitable ore for the Bessemer process throughout Europe, except in Sweden, which the recently discovered coal there will render more available.

The Siemens-Martin process of steel-making, superior to the Bessemer in requiring a less pure ore, has thus far produced so little that it can hardly be called a source of supply in the great market.

Steel rails are now so well made that they rarely break, except when the flange is punched, and this should be done only while the metal is hot, or the notch drilled and then slotted. Although a steel rail is generally thrice as strong as an iron one, when punched or the flange is cracked, the iron may be the stronger. The steel is made as soft as possible, say with $\frac{1}{3}$ per cent. of carbon, for not by hardness but by homogenity is it superior to iron. Usually a steel rail will carry one-fifth more dead load than an iron one; hence, for the same traffic, the steel rail, in comparison with the iron, should not be reduced in weight more than 20 per cent.

Buyers should require each rail to be permanently marked to indicate date, maker's name and quality, that subsequent use may determine which manufacture is best.

Traffic Capacity.—The amount of wear, or life of a rail, is usually expressed in tons passed over it before rejection; properly, the speed of travel should be taken into account, and 220,000,000 speed tons is a fair expression of the endurance of extra iron rail.

The average life of iron rails in England for ordinary traffic is about ten years; in and near London it is two years or less; on the Continent, from 12 to 15 years; and in Sweden, with less traffic than in England, from 15 to 18 years.

The weight passed over good iron rails before rejection has been found to average 10,000,000 tons. This may be taken to represent the life of extra iron rails, and six times that the life of good 56-pound steel rails. On the "London and North-western Line" steel rails have lasted twenty times as long as iron, and on the "Metropolitan Railway," where iron would not have lasted six months, steel will stand from three to four years.

In comparing the relative economy of superior iron rails and those of steel—prices of each per ton being taken at £7 and £11, and interest on capital 5 per cent.—the yearly saving per mile would be £4

where iron rails would last 15 years, and were used; £10 where they would last ten years and steel were used; and £78 where the iron rails would last five years and steel were used.

A table is annexed, showing the gross load in tons which each quality and weight of rail may be expected to carry during its life, and the conditions are stated therewith to aid in the selection of rail to accommodate a given traffic—an important matter, since many European railways are laid with too heavy rails, and American with too light ones. Equally important with the weight of a rail is a proper section. In England the double-headed rails are still generally used, and elsewhere in Europe the flat-bottomed pattern, as also in America. A specially bad section is the Erie 61-pound rail, which could be replaced by a 45-pound rail, well proportioned.

Prof. Rankin says the weight of the rails per yard in length should equal 15 times the greatest load on the locomotive drivers in tons. Perdonet, in France, takes 12 in place of 15. The writer, by adopting a section which permits a fish-joint stronger than the others in general use to be made, takes ten and less. Thus, for a 60-pound rail the weight on drivers is put at 6½ tons.

Fish plates of steel will enable rail to carry from 15 to 20 per cent. greater load than if iron were used of the same section; they will cost per ton about £1 less than steel rails, and the iron about £1 more than iron rails; hence the adoption of steel fish-plates will be of benefit even with iron rails.

Mr. Macdonald remarked that Mr. Sandberg, in taking 6½ tons weight per locomotive driver as a safe load on a 60-pound rail, differs from the best practice in this country. The "Philadelphia and Reading Railroad," on rails made with great care by the company, prefers not to exceed four tons on a 64-pound rail, and the rail section has been gradually increased, to counteract wear and tear from even this medium load.

On the "Erie Railway," $5\frac{4}{10}$ tons weight on the drivers has been found too great for best 70-pound iron rails, and with a speed, for heavy freight trains, of 15 miles per hour, should not exceed four and a-half tons.

Mr. Allen remarked that this was of great personal interest to him. His first railway report dealt with the question of weight upon drivers, and showed the need of keeping it below certain limits. If greater weight is to be carried, the number of drivers should be in-

creased; and the time will doubtless come when locomotives with eight, ten and even twelve drivers will be used.

In no way has more money been wasted in the construction and operation of railroads than by the increasing weight upon drivers, to the great injury of road-bed, rails and rolling-stock.

A regular meeting of this Society was held at its rooms in New York, Wednesday evening, Dec. 18th.

"A Record of some Experiments showing the Character and Position of Neutral Axes, as seen by Polarized Light," by Louis Nickerson, C. E., of St. Louis, Mo., was presented and discussed.

During the researches of Eaton Hodgkinson, published in 1842, he took the ground that the neutral axis in a beam shifted as the load was increased, and finally took position where the compressive strength of the material above it would be equal to the tensile strength of that below it. He fixed this for a cast iron rectangular beam about to break at one-seventh its depth from the top, because its resistance to tension, was one-seventh that to compression, and this was apparently proved by an inspection of the fracture of beams which were broken. In 1855, Henry Barlow made experiments to test this theory, in the course of which he claims to have established that the neutral axis of a rectangular beam always lies through the centre of gravity of the section, and recognizes, in addition to the tensile and compressive elements of strength in a beam, a third, due to the lateral adhesion of the fibres, and increasing with the deflection.

Each takes the transverse strength of a cast iron beam at about 2¼ times as great as it should be, according to its tensile and compressive strength, and records a theory in regard to the character and position of the neutral axis, differing from the other.

The experiments here recorded were made to reconcile the results obtained by Messrs. Hodgkinson and Barlow, and to discover whether the "lamination of material in planes normal to the direction of the pressure excited upon it," was due to a periodic action of force, or consequent upon tangential stress, imperfect cohesion of the material, or the running together of internal cells. Polarized light was sent through plates of glass under compression, either as beams or columns.

The difference in the effects caused by similar strains on two materials is relative; and that produced by a force upon glass is like that upon other substances.

The results sought for are from certain general laws of the doctrine

of forces, which must be the same for all materials—and modified, not changed, by any particular one; the transparency of glass and its bi-refractive quality when strained exhibits them to the eye.

In the experiments, structural differences were ignored. Glass, cast iron and steel are amorphous bodies, yet composed of segregated crystals, and under pressure exhibit a similar characteristic fracture. There is also a like ratio between their compressive and tensile strengths—that of glass appearing to be a mean of the other two.

The apparatus used was the one common for experiments with polarized light; a polarizer of glass plates, an analyzer of one plate blackened at the back, and a small brass clamp with thumb-screw to compress the pieces of glass experimented upon, either as beams or columns. These pieces, before pressure is applied, appear black in polarized light—glass in an unstrained or neutral state being impervious to it.

A slip, representing a beam, placed in the clamp, and the screw slightly tightened, shows at the top and bottom a clear space, enclosing a dark space; between which, under greater pressure, take sharper outlines; and colored curves, distinct and separate, appear, following the lines of strain. These increase in number and brilliancy with the pressure, and always move towards the dark and neutral space.

The experiments were made in consecutive steps; the application of force ranging from proportionately a very small tensile with a very large compressive strain, to that where the two were nearly alike, and were described at length.

Colored drawings representing the effects of polarized light upon the various slips of glass experimented with, were exhibited.

The results obtained show that the neutral axis is a flexible line, or plane, truly parallel to the top and bottom sides of the rectangular beam and passing through the centres of gravity of its sections *only* when the load is evenly distributed from end to end, or when the beam is infinitely long; and that when there is a local pressure, the neutral axis is more or less governed in its direction and form, by the strain passing from the point of local pressure towards the points of support.

The beams of Mr. Hodgkinson were broken at the centre by a blow, in which the neutral axis was located above the centre of gravity of the transverse section. From these experiments it is deduced that this

position is due to the application of the force, and not to the ratio of the tensile to compressive resistance.

In comparison with Mr. Hodgkinson's, Mr. Barlow's beams were, in proportion of length to depth, one half longer, and he naturally found the neutral axis more nearly horizontal and less distorted.

Glass beams, in length fourteen times the depth, show the neutral axis so nearly horizontal that he may have overlooked the variation, and it must be almost imperceptible in beams more in length than ten times the depth.

It is claimed that the neutral axis, as exhibited by polarized light, from the cohesion of material or other cause, is extended to a breadth, and cannot become a true line, until, in reference to the cohesion, the tensile and compressive forces are infinite. Also that its longitudinal direction, like the directions of lines of strain, is not any arbitrary one, but resultant from the relative qualities and quantities of all the forces in the beam—its evident place in Physics being that of still water between opposing eddies or vortices.

The pulsations of completely polarized light are confined to two directions—at right angles to each other.

In the drawings are represented two images of the same object, corresponding to these two directions—one being taken, and the analyzer revolved 90° for the other; they, for convenience termed positive and negative images, are pictures of strains in the beam or column normal to each other. In the first tubular bridges, a wave of "buckling" always followed a line 45° from the top, where the load was placed, even crossing the stiffening plates. Such strains may be called "strut strains," and their resultant in a beam is vertical. The principal strains in an ordinary beam are horizontal or "flange strains" —being tension in the bottom and compression in the top. Their resultant is also horizontal and normal to the first.

The drawings show that when the "strut" or "flange" strains increase, correspondingly the negative or positive images, as the case may be, grow brighter.

Many strains may exist in the same beam, crossing and then neutralizing each other, and yet elsewhere be individual and intact.

As glass is pervious to polarized light when strained, and impervious when unstrained, the light parts must be strained in proportion to their brightness, and the dark unstrained or neutral; as bi-refraction is caused by strain, both must be governed by the same laws. Further: the resultant angles of the strains and those of polarization

are rectangles, and as the strains change in character, so do the polar images change in correspondence; therefore the images are pictures of the strains.

Any space which is under no strain, whatever load is applied to the beam, must remain dark under all revolutions of the analyzer; each marks the crossing of the two resultant axes, that of the "strut" and of the "flange" strains.

The appearance of light around the neutral band is the first symptom of distortion in the positive image; soon faint segments of yellow appear at the bottom, occupying a large part of the space between the supports, and at the top varying with the application of the load.

As the pressure is increased the yellow from both edges moves forward towards the neutral band, becomes a zone, and a segment of red succeeds. Both continue to move, until the red becomes a zone, and is followed by a segment of blue, between which and the red there is a dark neutral line.

A second similar series may be brought out before fracture.

Mr. Barlow established the existence of a third and important element of strength in a beam, which increases as the beam is bent. The moment of this or bending resistance is equal to that of the applied force or bending stress, and their common line moves towards the primary neutral axes as the load is increased. This is shown by the dark lines described.

There are then neutral axes existent, amidst disturbing forces, of a beam which under increasing loads shortens in the top and lengthens in the bottom.

A transparent column under pressure exhibits a series of colored rings, glass showing from three to six at each end, and a softer material, as copal, wreaths of colored bands from top to bottom, a dark space always occurring between the blue and red, which marks an unstrained part of the column, or a union of equal and opposite forces.

To determine what these dark rings indicated, tests were made upon columns, which changed in form under pressure. These were brass tubes, $\frac{45}{100}''$ exterior, $\frac{35}{100}''$ interior diameter, and about $1\frac{1}{2}''$ long.

Submitted to compression until they assumed a permanent form, they all exhibited from end to end a series of extended rings, uniformly separated, or periodic waves.

Other steel tubes, also compressed, were examined, and an empiric

expression derived which will locate any wave in relation to another, the tube being homogeneous.

Hollow columns, if sufficiently under stress, within elastic limits, may be greatly strengthened by bands, placed where the waves would otherwise occur. It is inferred that one-third additional material will thus double the strength of the column. In conclusion, the law of periodicity of force in compression, and probably in tension, seems to be proved, and the law of lamination under pressure accounted for.

Discussion.

Mr. Macdonald. The experiments upon which formulæ in common use for the proportion and strength of beams are based were made upon cubes of the materials tested, and it is found that the constants derived are inapplicable to ordinary cases in practice.

Mr. Boller. A recent comparison of various standard formulæ for the strength of beams, made by taking a given beam and calculating, with each formula, its safe load, gave as follows: Two, 25 tons; one, 30 tons; and one, 37 tons. The last was from Mr. Baker's formula, in which he has introduced the resistance due to flexion. The beam taken was 3″ x 6″, and 5 feet long. Engineers should know more of the strength of materials. The formulæ used involve the application of constants ranging variously from maximum to minimum strength. These often differ widely, and therefore give uncertain results.

Mr. Macdonald. It is known that a beam, loaded so that its outer fibres by formula should be under a maximum strain, will stand a greater load. The constants employed in calculating the strength of a beam should be determined from experiments upon a similar beam of the same material, and not those given for direct tension and compression.

Prof. De Volson Wood. The point of greatest interest to him in the paper read is whether the neutral axis is a line or a space, as water in an eddy.

In regard to the neutral axis and strength of beams, as determined by ordinary rules, the fact is we assume in a bent beam that the extensions and compressions are proportional to the distance of the elements from the neutral axis, and take the modulus of tenacity or of crushing, as the case may be, for the modulus of rupture of the beam.

A beam proportioned in accordance therewith will have an excess of strength.

Thus take a rectangular cast-iron beam, as the best example in practice. According to theory, the mean value of the modulus of rupture should be 16,000 lbs., but it is seen by experiment to be 36,000 lbs.

Former writers do not explain this discrepancy, but simply admit a defect in the theory.

Mr. Barlow detected a new element of strength, which he called "Resistance to Flexure," a term which is unfortunate, as all the forces in a beam which resist bending are resistances to flexure. "Longitudinal Shearing Resistances" is a better term, and one now used.

This force is the resistance of the fibres to being drawn over each other. If there was no such resistance the fibres would retain their original length.

He found, by a critical examination of iron beams, that the traverse sections remained normal to the neutral axis during flexure, thus proving the existence of a force besides that which produces direct elongation and compression.

This is the longitudinal shearing resistance. Mr. Barlow also determined the laws governing it at rupture, and modified the formulas accordingly.

His experiments are the most weighty and valuable of any made upon beams, as far as theory is concerned. His formulas and constants agree with the actual strength for all sections which he used.

It is evident the ordinary law, that strains vary as their distance from the neutral axis, cannot apply to beams of ⌶ section; for, that it may apply, there must be at least a continuity between all the elements of the flanges and the web.

Mr. Barlow's formula for this case cannot be correct. In all ⌶ sections there is a peculiar combination of the strains about the angles where the flanges and web join.

Prof. Norton, by direct experiment, determined the fact of a transverse shearing resistance in beams, and the laws governing it in those of rectangular section. The deflections due to longitudinal and transverse shearing resistances tend respectively to diminish and increase that defined by Navier's theory.

Simple rules cannot be given applicable to the varied forms of beams in use. Constants deduced from experiment upon solid rect-

angular beams will doubtless apply to solid beams of all dimensions, but not to others.

Mr. BOLLER. It is best to make a beam proportioned similar to those to be used, break it, and deduce therefrom a constant.

The formulas for ⌶ beams are safer for thin than thick webs; say ¼″ web, and 4″ flange.

Prof. WOOD. The experiments of Baron Von Webber showed that the web had never been made too thin. Where the flange and web are joined there should be a large curve.

Mr. MACDONALD. In T. C. Clarke's description of the Quincy bridge there is a statement that 12-inch ⌶ floor beams, 15½ feet long, suspended in pairs from panel points about 12 feet apart, and carrying a single track of 4′ 8½″ gauge, scarcely deflected under a maximum engine load, which caused a strain upon the outer fibres at least equal to 14,000 lbs. per square inch, according to formulas in general use.

Prof. WOOD. Structures should not be proportioned in reference to the ultimate strength of the parts, but their elastic limits. Some very tenacious irons have a low limit of elasticity; while in other cases—certain grades of steel, for instance—elasticity is preserved under a strain equal to one-half the tensile strength.

The Secretary presented communications upon Mr. Nickerson's paper, from Gen. Barnard, Col. Merrill, Messrs. McAlpine and Fuertes, reading of which and further discussion were deferred until the meeting to be held February 19th next.

Influence of Pressure on the Spectra of Gases.—A foreign contemporary publishes the following information as an observation of M. Cailletet: When a spark from an induction coil is passed through a tube containing a gas under ordinary pressure, the light is feeble and presents in the spectroscope very indistinct bands. But if the pressure be slowly increased, the bands will become brighter and broader, producing in the end a continuous spectrum. Upon reaching a pressure of two hundred atmospheres the electric current ceases to pass.

REPORTS UPON THE TESTS OF THE WORTHINGTON PUMPING ENGINES—AT BELMONT.

Report of Experts and Engineers appointed to test the duty and capacity of the Worthington Pumping Engines at Belmont.

To the Select and Common Councils of the City of Philadelphia:

GENTLEMEN:—The undersigned, appointed by your honorable bodies to test the Worthington Pumping Engines at Belmont, beg leave to present the following report:

On examination it was decided to test Engine No. 2, which has been in operation during the past twelve months.

The tests were of two kinds.

First. The duty test, by which is meant the ability of the engine to perform a given amount of work, and is expressed in pounds raised one foot high with one hundred pounds of coal.

This test takes into account the actual resistance against which the engine works, is calculated from the known dimensions of the pump, the observed pressure in the pump main, and speed of engine, and is independent of the actual delivery of water into the reservoir.

Second. The capacity test, or actual discharge at the reservoir.

This is expressed in cubic feet or gallons, and the amount by which this falls short of the theoretic or calculated capacity of the pumps, represents the leakage through the pump valves, around the plunger, through joints, &c.

For the purpose of bringing the whole work within the period originally assigned, forty-eight hours, the two tests were conducted at the same time; observations of the delivery at the reservoir being conducted whilst those connected with the working of the engine were being made.

DUTY TEST.

Previous to the test, the pressure gages were carefully compared with standard test gages, and a certified statement of their variations obtained. The coal scales were tested and sealed by the official sealer of weights and measures. The pressure gages on the engines indicated the resistance, measured from the centre of the gage to the delivery in the reservoir. A float and gage rod marked the level of the water in the pump well. The whole resistance, or load, on the engine, therefore, is expressed in feet, by adding the height due to the indicated pressure on the gage to the vertical distance from the centre of the gage to the level of water in pump well. The

counter attached to the engines indicated every fourth stroke, and the reading was noted every half hour by actual count of the strokes.

The feed water for the boilers was accurately measured in a tank of ascertained capacity, and charged to the boiler as delivered. The correctness of the manner of measurement was verified at the commencement of the test.

The coal consumed was carefully weighed, one or more assistants being on duty in the fire room during the whole test, and having a constant supervision thereof.

Half-hour observations were taken of the engine counter, the indicated water pressure, height of well gage, steam pressure at engine and boilers, speed of engines, length of stroke, condition of vacuum, and temperature of feed water. These observations were made by not less than three persons at the same time, and their notes carefully compared and verified as the test progressed.

The measurement of feed water was constantly in charge of an assistant, and every separate charge of water to the boilers was entered in a book kept for the purpose.

The fires were carefully observed at commencement of test, steam in boilers being at forty-eight pounds pressure, and water in glass gages standing at two and one-half inches.

The test commenced at 4·40 P.M., on Wednesday, May 15th, and continued until Friday, May 17, at 5 o'clock P. M., being of forty-eight hours and twenty minutes duration.

SUMMARY OF RESULT.

		Hours.	Mins.
Duration of test,		48	20
Reading of counter at close of test,	959273		
" " " commencement,	924372		
Number of strokes as per counter,			34901
Counter indicating every fourth stroke	34901 × 4 =		139604
Average stroke per minute,			48·139
Diameter of water plunger in inches,			22·5
" " piston rods "			4
Mean area of plungers in inches,			391·33
" length of stroke,			49·347
Displacement of plunger in cubic inches,			19·311
" " " gallons,			83·6

Displacement of plunger in (water at temperature of 66° = 62·297 pounds per cubic foot), ...		696·2
Mean water pressure, in pounds, per sq. inch, . .		86·724
Height due to this pressure, in feet (water at 66°), . .		200·46
Distance from centre of gage to water in pump well, in feet, ...		17·28
Total height, including frictional resistance, in feet, .		217·74
Average steam pressure at boiler, in pounds, per sq. in.,		48·85
Average steam pressure at engine, in pounds, per sq. in.,		46·66
Vacuum at engine, in inches, ...		26.5
Average temperature of feed water, degrees, Fahr., .		129·59°
Coal charged to boilers, in pounds, . .	40330	
Ashes and clinkers, . 4349		
⅓ of this available for firing, ...	1450	
	38880	
Correction of weight to raise water at, Close of test to original level,	10	
Total coal for work of engine, ...		38890
Water charged to boilers, in cubic feet, .	5212	
Less leakage (temp. 138°, weight 61·52 pounds per cubic foot), ...	40	
		5172
5172 cubic feet × 61·52 pounds =		318181
Loss of water in boiler during test, pounds, ...		530
Total water evaporated in pounds, . : . .		318711
Pounds of coal to evaporate this amount of water, . .		38880
Evaporative power of boilers, $\frac{318711}{38880}$ = pounds of water, with one pound of coal, . .		8·19

The correction of weight of coal is obtained in this way. At the close of the test, the water in boilers was 0·17 inches lower than at commencement. The engine is therefore charged with coal sufficient to bring the deficiencies of water (530 pounds) from 130°, the temperature of feed water, to temperature of steam, at 48 pounds, 295°·07, or 10 pounds of coal.

On the other hand, by reason of this deficiency, the boilers had evaporated so much more water than appeared to be delivered to them, and had done it without the use of this additional ten pounds;

consequently, 530 pounds has been added to the weight of water delivered by the feed pump.

The duty of the engine is thus calculated.

Duty calculated from actual evaporation—

Displacement of plunger in pounds per stroke.		Stroke of engine in hours & minutes. 48 20		Height of delivery in feet.

$$\frac{696.2 \quad \times \quad 139{\cdot}604 \quad \times \quad 217{\cdot}74}{38890 \text{ pounds of coal.}} \times 100 =$$

54,416,694 pounds raised one foot high with 100 pounds of coal, being in excess of the guaranteed duty, 8·83 per cent.

On the basis of an evaporation of 9½ pounds of water, with one pound of coal, which the contract with Mr. Worthington allows, the duty would be 63,120,707 pounds, or an excess of 26·24 per cent. over the contract requirement.

Capacity Test by Weir.

The quantity of water discharged at the reservoir was measured over a Weir, carefully constructed under the direction of Mr. T. H. Risdon, a gentleman practically acquainted wilh this mode of measuring water. Under his directions also the observations and calculations were made. From these it appeared that the pumps delivered into the reservoir, in 48 hours and 20 minutes, 1,500,584·52 cubic feet of water, equal to 11,225,122 gallons, or at the rate of 5,573,853 gallons in 24 hours; being 11·47 per cent. in excess of 5,000,000 gallons guaranteed by the contract.

The discharge of the pumps, calculated from the displacement of the plungers, was 5,795,200 gallons in 24 hours, being more than that determined by Weir measurement by 3·8 per cent.

It will not be correct to assume that the whole of this difference is due to leakage by and through the pump, and in order to ascertain as nearly as possible the amount due to that cause, it may be observed that during the whole test some portion of the injection water for the condenser was taken from the pump main, the suction injection at the high temperature of the river not furnishing sufficient. This quantity was not less than one hundred gallons per minute, which would make the loss by leakage through the pump not exceeding 1½ per cent.

The tests, both of capacity and duty, have been made with great care, and every precaution taken to obtain a correct result.

The conclusion from the facts and figures given is that the engines are fairly and easily performing a duty considerably beyond the guarantee.

The engines worked during the whole test with remarkable smoothness and precision, with scarcely a perceptible variation of speed or length of stroke, and the character of workmanship throughout appears unexceptionable.

JACOB G. NEAFIE,
HENRY L. HOFF,
W. BARNET LEVAN,
GEO. H. BAILEY,
ISAAC S. CASSIN.

May 31, 1872.

Report of the Expert selected by the Citizens' Committee of Thirty, upon the Trial of the Belmont Pumping Engines.

It will be remembered that Henry P. M. Birkinbine was selected by the Committee of Thirty of the Citizens' Municipal Reform Association to represent them at the test of the engines of the Belmont Water Works. The following is a complete copy of the report which he has made to the Committee:

JAMES DOUGHERTY, Esq., Chairman of the Committee on Water, Citizens' Municipal Reform Association:

DEAR SIR,—When your note of May 10th was received, informing me of my selection as expert for the Citizens' Municipal Reform Association, in the test of the engine and pumps at the Belmont Water Works, I communicated with the members of the Committee previously appointed by the City Councils. At that time all the preliminary arrangements had been made, the engines, pumps and boilers had been thoroughly overhauled and cleaned, and the committee had examined the engines and pumps when they were taken apart, being unanimous in reference to the integrity of the workmanship of the machinery. So far as I was able to judge, the construction of the engines is satisfactory.

The arrangements were made to commence the test on May 15th. Before noon that day all parties were represented, and the test was commenced at twenty minutes to five P. M., being continued until May 17th, at five o'clock P. M., a period of forty-eight hours and twenty minutes.

The engine was handled in a masterly manner by Mr. Jenkins, foreman of the works where the engine was built, assisted by Mr. Root, who set the engine up, and by the city engineers on duty at the works.

The following memoranda of parts of the engine and boilers were furnished me:

Steam was generated in six (6) boilers, each having two (2) mud-drums attached.

Diameter of boilers, 54 inches.

Length of boilers, 30 feet.

The convex heads increase the length of the boiler at the centre to 30 feet 10 inches.

Diameter of mud-drum, 28 inches.

Length of mud-drum, 22 feet.

Total grate surface, 264 square feet.

Total heating surface—

In boilers,	1479 square feet.
In mud-drums,	1969 square feet.
	3448 square feet.

Compound Duplex Pumping Engine—Diameter of high-pressure cylinder, 29 inches.

Diameter of low-pressure cylinder, 50½ inches.

Diameter of pump-plunger, 22½ inches.

Diameter of piston-rod of pump, 4 inches.

Travel of piston between cylinder-heads, 50 inches.

Average displacement of pump-plunger, per stroke of 48 inches, 81·315 gallons.

Height of lift from water in Fairmount dam to overflow of reservoir, 208·03 feet.

Pumping main, 30 inches in diameter.

Pumping main, 4167 feet long.

In conducting the tests, observations at the engine-house were made every thirty minutes, and carefully recorded.

First. Of the pressure of steam in the boilers. This was maintained at an average of 48·85 pounds, never falling below 48 pounds, and reaching 50 pounds at but one observation.

Second. Of the pressure of steam at the engine gauge. This averaged 46·66 pounds, never falling below 45 pounds nor exceeding 47·5 pounds.

Third. Of the vacuum in the condenser. This was maintained nearly uniform at 26·5 inches, varying but 0·25 of an inch. As the

plunger displacement was to be considered as the capacity of the pump, I inquired if water for condensing the steam would be taken from the ascending main, and was assured that it would not be done. After the test was well under way, water for condensing steam *was* drawn from the ascending main, as the engineers in charge stated that otherwise it would be impossible to maintain the vacuum. To this I objected, as an engine constructed so that a part of the condensing water had, under ordinary circumstances, to be drawn from the main, under a pressure of over 200 feet, is in that respect defective.

The temperature of the water was 66°.

The amount of water thus taken from the ascending main is impossible to determine.

Fourth. Of the guage on the delivery end of one of the pumps. This averaged 86·724 pounds, but, as the index vibrated from five to eight pounds at each stroke of the pump, the readings were necessarily imperfect. The pressure indicated by the gauge is probably greater than the actual pressure due to the height of the lift above the gauge (190·75 feet), and the friction on the ascending main. Taking the average reading of the gauge as correct, and adding the height of the gauge above the water in the pump well, the lift will be equal to 217·74 feet.

Fifth. Of the number of strokes. The average was 48·138 strokes per minute; never by count falling below 47, and in but two instances observed increasing to 50.

Sixth. Of the length of stroke. When the engines were started, before the test began, the stroke was about 48 inches, which the city's engineer in charge reported was the ordinary stroke of the engine. This allows one inch at each end for clearance, to meet an emergency, such as an increase of steam pressure, or the imperfect closing of the pump-valves.

By an arrangement of valves the stroke was increased to 49·25 inches, when the test began, and after four hours it was worked up to 49·375 inches, being maintained at the same stroke for most of the test, never falling below 49 inches. The average during the entire test was 49·347 inches.

To this increase of stroke I made objection, as it caused the engine to be worked in an unusual manner, and increased the capacity of the pumps $2\frac{74}{100}$ per cent., without requiring any more steam than was necessary to make the ordinary stroke of the engine, thereby augmenting the duty.

Seventh. Of the amount of feed-water. This water was supplied through a measuring tank graduated to 20 cubic feet; 19 cubic feet was the usual charge. When this was pumped out, the tank was replenished. The total amount of water suppled to the boilers was 5212 cubic feet. A leak discovered in the feed-pipe, which was estimated to have lost 30 cubic feet, reduced the amount of water evaporated to 5172 cubic feet, or 318,181 pounds.

The average temperature of the feed-water as it entered the boiler was 1338.

At the end of forty-eight hours the level of the water in the boilers was found to be 0·75 of an inch lower than when the test began.

This will increase the amount of water evaporated 48·13 cubic feet, or 2961 pounds; but as the water was simply converted into steam in the boilers, it was at a great saving of fuel over that supplied from the feed.

The total amount of water evaporated was, therefore, 5220·13 cubic feet, or 321,142 pounds.

Eighth. Of the coal consumed. The coal for the test had been carefully selected, screened, picked and stored in the boiler-room.

At the commencement of the test steam was at 48 pounds, the fires in proper condition, and water $2\frac{1}{2}$ inches in the glass gauge.

Eighteen hundred pounds of coal were weighed and delivered in front of the boilers. When this was burned another charge of 1800 pounds was weighed out: this was continued until the close of the test, except the last two charges, when but 1200 pounds was taken for a charge.

The amount of coal perceptibly fell off towards the close of the test. Attention was called to the fact that, the conditions remaining the same, there could be no difference in the amount of fuel required to do the work toward the close of the test or at any other period during the time.

And, while at the termination of the test the fires might apparently be as good as at the commencement, they could not possibly be of the same intrinsic value. That this position is correct is evident from the fact that, during the entire test, 0·287 of a pound of coal was consumed per stroke of the engine; that during the first 40 hours, 0·3118 of a pound of coal per stroke was used, and during the last 8 hours and 20 minutes but 0·171 of a pound of coal per stroke was consumed. As there was no change in the work done, there must have been a

deficiency in the amount of coal. This deficiency, estimating the last 8 hours and 20 minutes, to require the same amount per stroke as was consumed per stroke in the entire test, will be fully 3035 pounds.

The total amount of coal consumed under the boilers was 40,130 pounds, and the total amount of ashes, clinker and unburned coal taken from the ash-pit was 4849 pounds. A portion of this was screened in a sieve and picked, the amount of unburned coal being estimated at 1450 pounds, which was deducted from the coal burned. Objection was made to this.

First. Because the coal used was not ordinary merchantable coal, as it should have been, but had been carefully cleaned of all foreign matter, as is evident from the small amount of refuse, less than 11 per cent., the usual allowance of merchantable coal being 20 per cent.

Second. Because the small amount of unburned coal had no commercial value.

The deficiency of feed-water, amounting, as before explained, to 2961 pounds, would have required at least 357 pounds of coal additional had it been supplied from the feed instead of steam being generated from the water contained in the boiler.

The engine should therefore be charged with 40,130 pounds of coal burned under boilers, 3035 pounds of coal deficiency in quality of fire, 357 pounds of coal deficiency in water; total, 43,522 pounds.

Ninth. Of the evaporating power of the boilers. The total amount of water evaporated during the entire test, with the loss of water in the boilers added, was 324,103 pounds. This divided by the coal chargeable to the engines, will show that the boilers evaporated 7·447 pounds of water by the consumption of one pound of coal. This is certainly very satisfactory working evaporation. The contract for the engine specifies that unless the boilers evaporate 9·5 pounds of water with one pound of coal the engines are to be credited with the difference. As the results contemplated by this clause of the contract are rarely if ever achieved in practice, it certainly cannot be considered in the calculation of working duty of the engine.

Note. Wicksteed, in a table of results of the evaporating power of different boilers, shows 8·687 pounds to be the best recorded result. See "An Experimental Inquiry concerning the Cornish and Bolton and Watt Pumping Engines," &c., by Thomas Wicksteed, London. James Weale, table No. 5, column 21.

Chief Engineer Isherwood, United States Navy, in his experiments at the New York Navy Yard, upon the comparative evaporative efficiency of coal, gives 4·7089 as a fair average, and a waste of 20 per cent. in ashes, fine coal, &c. See "Engineering Precedents," Vol. 2, page 87.

In the experiments made by the American Institute last fall, the average actual evaporation per pound of coal, with different boilers in competition, was found to vary from 7·07 to 8 pounds. See "Journal Franklin Institute," No. 557, page 389.

Tenth. Indicator cards were taken from the high-pressure cylinder, the low-pressure cylinder, the delivery side of the pump, and the pumping main immediately at the pump.

These show that the steam is not used expansively in the high-pressure cylinder; that the principal work of the low-pressure cylinder is that done by the vacuum produced by the condensation of steam; the increased area of this cylinder is its great advantage; that so far as the steam end of the machine is concerned, no marked economy is possible. The pump card is perfectly satisfactory, showing a remarkable uniformity of pressure the entire length of the stroke; the actual delivery of the pump must be nearly equal to the calculated displacement of the plunger; the amount could not be ascertained, as a portion of the condensing water was taken from the ascending main, as above stated.

Eleventh. Of water flowing into the reservoir. This was measured by passing it over a weir, arranged to use the formula of J. B. Francis, civil engineer. A hook gauge was used. It was graduated to read to the one-thousandth of a foot, and the readings were taken every five minutes. These measurements may be relied upon as correct, and are as follows:

First twenty-four hours, ...	5,584,926	gallons.
Second twenty-four hours, ...	5,559,318	"
Twenty minutes, ...	71,124	"
Total, ...	11,218,368	"

The total number of strokes during the test was 139,604, and the actual amount delivered into the reservoir 80,358 gallons per stroke, a loss of 3·242 gallons per stroke, probably used for condensing steam.

The above statement exhibits the fact that the test was conducted to show the utmost that can be done by the engine under the most favorable circumstances. The results must, therefore, be considered as theoretical when calculated in accordance with the contract as interpreted by the committee appointed by City Councils, for they do not exhibit the fair working value of the engines, fired with merchantable coal and run as under ordinary circumstances.

It would be manifestly unjust to take an experimental result like the above as a standard of comparison for the economic working of this class of engine.

Charging the engine with the amount of coal burned, and that necessary to make up the deficiencies as above, 43,522 pounds, and crediting the engine with the actual work done, viz., raising 93,485,-513 pounds of water 208 feet, will give an actual working duty of 44,679,000 pounds.

That this estimate is correct is evident from the calculations made of the average duty of these engines during 1871, taken from the report of the Chief Engineer, page 20. This gives 37,970,173 pounds, or, from calculations made from records kept in a book in the engine-house of the work done during the previous month (April), when the average duty was 39,232,500.

While the engines as tested and calculated meet the requirements of the contract, they are below the representation made to Councils before the contract was made, namely, 67,969,000 pounds as an average annual actual duty.

It is but justice to the builders to say of the engine tested, that it is not only well built but operates smoothly and regularly, and is fully up to the guaranteed capacity, but not to the duty.

Respectfully submitted.

HENRY P. M. BIRKINBINE.

June 6th, 1872.

New Material for Moulding.—M. Müller describes in a French contemporary a process of forming ornamental and useful objects of pure silica. His process consists in obtaining the silica in form of an impalpable powder—(probably by precipitation)—which is then formed into a paste and moulded. The form is then heated to bright redness, when the grains fuse together, become very coherent and form objects of great durability.

Chemistry, Physics, Technology, etc.

BIELA'S COMET AND THE METEORS OF NOVEMBER 27TH.

By Professor Daniel Kirkwood.

The fact that comets on their approach to the sun have at times undergone the process of dissolution is abundantly sustained by recorded observations. The latest and most remarkable instance of such disintegration is that of Biela's comet. This body completes its revolution about the sun in a little more than six years and eight months. Shortly before its perihelion passage in January, 1846, it was seen to separate into two distinct fragments. Astronomers, anxious to see whether the parts had remained separate during an entire revolution, awaited the return in 1852 with more than ordinary interest. The *two comets* appeared at the predicted time; their distance from each other having increased to more than five times that of the moon from the earth.

At the next return, in May, 1859, both comets escaped detection. This was attributed solely to the fact that the relative positions of the comets, the earth, and the sun, were unfavorable for observation.

It will be noticed that three periods of the comet are very nearly equal to twenty years. Hence the perihelion passage of January, 1866, like that of 1846, was in circumstances favorable to telescopic scrutiny. A diligent watch was maintained during several weeks for the expected wanderers: the search, however, was without success. It was accordingly inferred that the same cause which had produced the bi-partition in 1845 had occasioned a still further separation, so that the dissevered fragments had become invisible. The comets were again due in September, 1872, but escaped, as before, the most powerful telescopes.

The orbit of the original comet intersected that of the earth at the point passed by the latter about the 29th of November. A collision of the two bodies was therefore inevitable in case they should both reach this point of intersection at the same time. To quiet the apprehension of such a catastrophe, M. Arago showed that a collision could not reasonably be expected for thousands or even millions of years to come. It is evident, however, that the probability of impact must be vastly increased by the disintegration of the comet and the diffusion of its fragments around a considerable arc of the orbit. Now, as it is well known that the comets connected with the meteoric streams of August 10th and November 14th have been for many cen-

turies in the process of dissolution, it is altogether probable that the breaking up of Biela's comet did not commence with the *visible* separation in 1845. Analogy therefore led astronomers to expect the appearance of meteors—the products of disintegration—about the last of November. The fact was noticed several years since that a considerable number of meteoric stones had fallen at this epoch. It is also known that a shower of falling stars was observed in France on the 29th of November, 1850.

Now as the greater part of the matter which constituted the comet of Biela must have passed the earth's orbit (in 1872) but a few weeks previous to the earth's arrival at the point of intersection, it seemed not improbable that parts of the cluster might still be passing during the last days of November. Professor Newton, of Yale College, actually detected these straggling fragments on the evening of November 24th, 1872. During five hours he counted 250 meteors, over three-fourths of which radiated from Gamma Andromedæ. A more remarkable shower, however, was observed in Indiana on the evening of November 27th. Professor Joseph Tingley, of Greencastle, counted 110 in forty minutes. This would give 165 per hour for one observer. But according to Professor Newton, the whole number visible at any station, when the sky is entirely clear, is five times the number seen by a single observer. The enumeration by Professor Tingley accordingly indicates an actual fall of 825 per hour. At Princeton, Indiana, Professor D. Eckley Hunter, with assistants, counted 70 meteors in thirty minutes; the position of the observers being such that more than one-half of the sky could not be seen. Again on the evening of December 3d, at about 10½ o'clock, an extraordinary meteor was seen at Bloomington, Indiana. Its apparent magnitude was estimated at one third that of the full moon. Its light, which was of a bluish tinge, illuminated, like a flash of lightning, all objects on which it fell. It appeared a little North of East, at an altitude of about 35°, and the direction of its motion was nearly conformable to the radiant observed by Professor Newton on the 24th of November. It seems therefore not improbable that it may have been a straggling member of the same group.

As the meteors of this cluster are doubtless the *debris* of Biela's comet, if we find the epoch at which the original body would have crossed the earth's orbit *near* the 29th of November, we may regard the collision of our planet with some of the large fragments—and hence a grand meteoric display—as highly probable at the same period. An easy calculation, which need not here be repeated, gives

the last of November, 1892, as such an epoch. The phenomena will doubtless be looked for with a very lively interest.

Bloomington, Ind., Dec. 5th, 1872.

BITUMINOUS COAL; ITS ORIGIN, VARIETIES AND A FEW OF ITS SPECIAL USES.

The substance of a paper presented at the Dubuque Meeting of the American Association for the Advancement of Science.

By E. B. Andrews, of the Ohio Geological Survey.

(Continued from page 69.)

In the ooze the *Stigmaria* almost reveled, penetrating it in every direction, and these curious vegetable forms with their spreading rootlets are bound in the greatest abundance in cannel coals, all flattened but in exquisite preservation. The existence of so many *Stigmariæ* in the cannel coals, the beds of which extend often for many miles, almost necessitates the conclusion that they grew *in situ.* If the *Stigmaria* is always a true root of *Sigillaria*, or other tree, as held by Dawson and others, we must conclude that trees, having their roots attached, grew in the wettest parts of the marsh, which were, therefore, not open lagoons as some have supposed. But Dawson asserts that "*Sigillariæ* grew on the same soils which supported Conifers, *Lepidodendra, Cordaites* and ferns, plants which could not have grown in water." He also claims that most of the underclays which, so far as I know, universally contain rootlets of *Stigmariæ* "are, in short, loamy or clay soils, and must have been sufficiently above water to admit of drainage."

These views require us to believe that the *Stigmariæ* could not have grown where they are found in cannel coal, but were floated to their present places as detached fragments.

If thus floated we should expect that they would show sometimes local accumulation on drifted heaps. So far as my observations go, they are very evenly distributed over the whole cannel coal area. Moreover, if detached and floated bodies and afterwards buried in the accumulating mud, we should naturally expect them also to go to decay and form vegetable muck similar to the surrounding mass. On the other hand, Lesquereux, Goldenberg and others hold that the true *Stigmaria* was an aquatic plant. Lesquereux thus writes: "It is my belief that the genus *Stigmaria* does not represent tree roots, but floating stems, of which species of the genus *Sigillaria* constitute the flowers or fruit-bearing stems." It was, if I understand his views, only under favorable circumstances that these stems prodeced the

stalks, or more properly trunks, by which the fructification was secured. By this theory it is certainly more easy to explain the vast number of *Stigmariæ* found in cannel coals. By it we may perhaps also account for the equally great numbers of *Stigmariæ* found in some of the sand rocks of the lower Coal Measures of Ohio, in which *Sigillariæ* are but seldom found. Since we often find *Stigmariæ* in the bituminous coal the "floating stem" theory would harmonize with the other opinion of Lesquereux, arrived at after careful study of modern marshes and peat-bogs in Europe and America, that the coal was formed in similar marshes, skirted by the ocean, which would furnish the needed conditions for the growth of such aquatic vegetation as he regards the *Stigmariæ* to be. With the questions of physiological botany involved in the determination of the generic affinities of this strange plant I have nothing to do; they belong to the palæobotanists. Schimper, in his great Work on *Vegetable Palæontology*, after giving the views of different authors, says, "We conclude that, admitting the radical nature of the *Stigmariæ*, we remain still very doubtful as to their generic determination, and still more as to their specific reference."

In a seam of coal, which I traced for many miles in West Virginia, the coal in one locality is chiefly resinous and bright, further on it passes into a dry splint, and at other points changes into cannel. At one place the vegetable mud, which formed the cannel, was deposited upon a floor of accumulated vegetable matter which now constitutes a layer of splint coal. This mass of vegetation had had its day at the surface when that surface was much dryer, but had afterwards sunk in the depression of the marsh which formed the muck basin. In another place the cannel coal has over it a layer of splint. In the latter case the condition of things in the original forming period would resemble that of some of our present marshes, where we find the vegetable ooze below, covered by a quaking surface of growing vegetation, including, sometimes, trees of considerable size. If such a marsh were buried under a heavy mass of sedimentary matter, and chemical reactions were to take place similar to those of the coal era, we should have something akin to cannel coal below, and above, either a highly bituminous or splint coal as the case might be.

These general views of the origin of cannel coal I give because they are the results of independent observation on my part. Other geologists have expressed views essentially the same. Lesquereux, who has given much attention to peat bogs and other forms of marshes and their vegetation, has stated that "cannel coal has been formed

under water from more decomposed vegetables." Dr. Newberry long since declared that cannel coal was formed from finely macerated vegetable tissues accumulated as a carbonaceous mud. Dawson attributes cannel coal to "vegetable mud," and his view is endorsed by Sir Charles Lyell.

Ashes in Coals. The variation in the percentage of ash in coals is very great. It may arise from these causes: First, the coals may have been formed from different kinds of vegetable tissues, which themselves contained varying quantities of ash. It is well known that the different parts of a modern tree, the bark, wood, leaves, &c., give different amounts of ash. Hence coal formed from different parts of the ancient vegetation would doubtless show similar differences. The least ash found in any Ohio coal is 0·77 per cent., and another sample, from the same part of the same seam at another location, a mile or more away, gave 0·85 per cent. These samples contained a very large amount of mineral charcoal, more than I have ever found in any other seam of coal. No examination by the microscope has been made in this case to determine what parts of the plants have formed the mineral charcoal. Dawson has found in the mineral charcoal of the Nova Scotia coals *fast tissues* from the inner bark of *Sigillaria* and *Lepidodendron,* especially of the former, *discigerous wood vessels* and *scalariform vessels* of the same and other forms of plants, *vascular bundles of ferns* and *epidermal tissues.* It is probable that the more woody matter of the trees constituted no inconsiderable part of the usual mineral charcoal, and the ash of this would be less than that of coal formed more completely from leaves and from the costical layers. Samples for analyses selected with great care might determine this point. Second, the quantity of ash would be in proportion to the waste and decay of the vegetation. The ash or inorganic matter of the plant would remain and accumulate, while, in the decay, the organic portions might be entirely dissipated, as is seen in the rotting of wood in our forests at the present day. The more extensive and longer continued the decay, the larger the amount of ash in the final residuum of coal. Third, the ash is increased by the deposition of sediments from overflows of the coal-marsh by muddy waters. The sediment would become intimately mixed with the whole vegetable mass. In some seams of coal we find these sediments so exceedingly fine that they leave a film upon the horizontally accumulating laminæ thinner than the most delicate tissue paper. Sometimes these sediments are so great as to make the ash excessive and the coal practically worthless. In the ordinary

bituminous coals of Ohio Prof. Wormley has found the average ash of 88 samples from south-eastern Ohio to be 4·718 per cent., and that of 64 samples from north-eastern Ohio to be 5·120 per cent.

The quantity of ash in cannel coals has a very wide range of variation. This might be expected, for the shallow water, standing perhaps a good part of the time in the places where cannel coal is formed, would be an almost constant bearer of sediments, especially if such shallows had openings, wider or narrower, with the ocean through which such sediments might be introduced. The existence of such openings or channels may be assumed from the forms of marine life which entered the inner water-areas where the cannel was formed. Furthermore, these interior shallows being the lowest parts of the marshy area, the waters draining into them from adjacent higher grounds would bring in more or less earthy matter. For these reasons it is hardly to be expected that cannel coal would yield a light ash. The smallest ash I have seen recorded is 2 per cent., while the largest may be 30 or 40 per cent., or even more. Many cannel coals are too earthy to be of any value.

I give some analyses of coal ashes made by Prof. Wormley.

	No. 1.		No. 2.	
	Per cent. of ash.	Per cent. of coal.	Per cent. of ash.	Per cent. of coal.
Silicic Acid,	49·10	1·645	37·40	0·2880
Iron Sesquioxide,	3·68	0·123	9·73	0·0749
Alumina,	38·60	1·293	40·77	0·3139
Lime,	4·53	0·152	6·27	0·0483
Magnesia,	0·16	0·005	1·60	0·0123
Potash and Soda,	1·10	0·037	1·29	0·0099
Phosphoric Acid,	2·23	0·075	0·51	0·0039
Sulphuric Acid,	0·07	0·002	1·99	0·0153
Sulphur (combined),	0·14	0·005	0·08	0·0006
Chlorine,	Trace.	Trace.	—	—
Total,	99·61	3·337	99·64	0·7670

No. 1. Ash from Youghiogheny coal, Western Pennsylvania.

No. 2. Ash from J. Sall's coal, Pigeon Creek, Jackson Co., Ohio.

In No. 2 the ash is very light, and nearly all of it may have been derived from the original vegetation. It contains more iron and sulphuric acid than No. 1 but much less phosphoric acid. In both cases the larger part is made up of silicic acid and alumina.

Sulphur in Coals.—This is a deleterious element found in all coals, not excepting the anthracites which have been subjected to a heating process sufficient to expel the bituminous portion. In bituminous coals it exists in different combinations. A part of it is combined with iron to form the bisulphide; a part passes off with the volatile hydrocarbons; a part remains with the fixed carbon of the coke, and a little remains in the ash. A sample of Youghiogheny coal analyzed by Prof. Wormley, gave a total sulphur of 0·98 per cent. Of this sulphur (only) 0·097 per cent. was combined with iron as a bisulphide; 0·223 per cent. passed off with the volatile matter in coking; 0·653 per cent. was found in the fixed carbon, and 0·007 per cent. remained in the ash.

So far as I know, chemists have not yet ascertained the exact nature of the combination made by the sulphur with the fixed carbon. Whether the sulphur combines with the carbon of the coke in any known form of sulphide would appear doubtful from the volatile character of such compounds, which would apparently necessitate their elimination in the process of coking. From the analysis above given, it is very obvious that the common notion that the sulphur in coals is in combination with iron, is quite a mistaken one. This is further illustrated by the following table of analyses, by Prof. Wormley, showing the per cent. of sulphur in several different coals with that of the iron, and also the proportion of sulphur that could have been combined with the iron.

Sulphur in coal, . .	0·57	1·18	0·98	2·00	0·91	0·86	0·51	0·74	4·04
Iron in coal, . .	0·075	0·742	0 086	0·425	0·122	0·052	0·102	0·102	2·05
Sulph. req. by the iron,	0·086	0·848	0·097	0·486	0·139	0·06	0·116	0·116	2·343

These facts are most interesting, and, as will be seen presently, have great practical importance.

While the proportion of sulphur of the bisulphide to the total sulphur in different coals are various, it will also be seen that the proportions of that which passes off with the gases are equally various. Among Prof. Wormley's analyses, I find the following:

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7
Sulphur in coal, . .	0·49	0·93	0·91	0·68	0·57	0·56	0·98
Sulphur left in coke, .	0·082	0·015	0·007	0·30	0·43	0·46	0·66
Difference passing off in gases,	0·408	0·915	0·903	0·38	0·14	0·10	0·32

No. 1. Coal of lower bench of Straitsville (Ohio), seam.

No. 2. " middle " " " "

No. 3. " lower part of seam, J. Sells, Pigeon Creek, Jackson Co., Ohio.

No. 4. Coal of upper part of seam, J. Sells, Pigeon Creek, Jackson Co., Ohio.

No. 5. " Jackson Hill seam, Jackson Co., Ohio.

No. 6. " Briar Hill seam, Youngstown, Ohio.

No. 7. " Youghiogheny seam, Western Pennsylvania.

For gas-making, the less sulphur entering the gas the better, since it must all be removed by purification. For the blast furnace, the less sulphur remaining in the coke the better, for it is the sulphur in the coke which is injurious and not that in the volatile hydro-carbons, which pass off in the top of the furnace stack. In some cases, however, where the gas carries with it most of the sulphur, the gas may be so superior in illuminating power as to warrant its use, notwithstanding the increased cost of purification. For example, the average sulphur of the whole Straitsville seam, of eleven feet in thickness, is 0·792 per cent. Of this, 0·683 per cent. enters the gas, but the illuminating power being, on an average, eighteen candles, the gas is preferred to that made from the Youghiogheny coal, into which there enters only 0·32 per cent. of sulphur, but has an illuminating power of but fourteen candles.

In the evolving of gas from coals, a part of the volatile combustible matter condenses into tarry matters, and has to be deducted in our calculations from the total gaseous product, the remainder being the fixed or permanent gas. The difference between the whole volatile combustible product and the permanent gaseous product is often very considerable, and this difference varies in different varieties of coals. This subject has been so admirably set forth by Prof. Wormley, and is withal of so much practical importance, that I quote from him the following facts: "A coal which contained only 27·70 per cent. of volatile combustible matter evolved 3·82 cubic feet of fixed gas per pound, whilst another, which contained 38·80 per cent of volatile combustible matter, evolved only 3·03 cubic feet per pound." Of fourteen samples tested, the average volatile combustible matter was 33·54 per cent., and that of the permanent gas in cubic feet per pound of coal was 3·306. Gas works practically obtain more gas per pound than the chemist, doubtless through a re-distillation of a part of the tarry matter. Prof. Wormley also suggests that at such works the measurement is taken at a higher temperature, a difference of five degrees changing the volume of gas about one per cent. "From a fair average of Youghiogheny coal," Prof. Wormley "obtains only about 3½ cubic feet per lb., whereas, in the ordinary manufacture of illuminating gas, this coal, as is well known, yields about four cubic feet per lb. of coal."

The sulphur in coals is derived from two sources, viz., from the vegetable itself and from the water of the ocean. Bischof states that "the ash of beechwood contains as much sulphuric acid and peroxide of iron as would suffice to form iron pyrites amounting to $\frac{1}{48077}$ of the weight of the wood. The peroxide of iron would yield 23 times as much pyrites if sulphates were brought in contact with it from outwards. Fir wood can give rise to the formation of ten times as much iron pyrites as beech wood." The large amount of carbonaceous matter of the coal vegetation acting upon the alkaline and earthy sulphates in the sea water, would, with the aid of proto-carbonate of iron, form more or less pyrites, and Bischof asserts that it is actually formed in this way. He, however, limits the action upon sulphates, as far as it goes on in the sea, to the decomposition of sulphate of lime. But these chemical reactions only explain so much of the sulphur as is combined with iron as pyrites or bisulphide. It is barely possible that so large a body of decomposing vegetable matter might set free more sulphuric acid from the sulphates than there was iron to combine with, and the excess, probably losing its oxygen, went to form new combinations with the organic matter of the decomposing vegetation.

It is impossible to assign a reason why one coal should contain more sulphur than another. If it came exclusively from the inorganic part of the vegetation itself, it is easy to see, as in the case of the ash already discussed, that the more extensive and longer continued the decay of the vegetation, the larger the accumulation of sulphur in the final residuum of coal; but doubtless only a small part came in this way.

The sulphate being always present in sea water and probably in uniform quantities, and there always being iron enough in the water,—certainly in the era of the lower Coal Measures of Ohio, where the iron is everywhere precipitated as a carbonate of the protoxide or siderite,—we should naturally expect from uniform conditions uniform results. But in fact no two seams of coal contain the same amount of sulphur, and the same seam shows not only in different locations very different amounts, but also in different parts in its vertical range at the same location.

Rapidity of formation of Coal.—It is probable that the buried vegetation passed through its changes and became hard and perfect coal in a much shorter time than is generally supposed. In Perry county, Ohio, I found near the base of a sand rock over the Nelsonville or Straitsville seam of coal a perfect bowlder of coal, a flattened disk

nearly four inches in diameter and two and a half inches deep. It was found about thirteen feet above the seam of coal, there being in the interval a foot of sand rock and twelve feet of shales, sandy at top and clayey at bottom. The bowlder is a fragment torn from some seam of coal and rounded by attrition in the moving waters which brought in the sand of the sand rock. The structure of the coal appears to be that of the Straitsville seam. This seam, at a location a few miles from the place where the bowlder was found, has, over a limited area, been violently torn away by waves or some powerful current of water, and the excavation filled with mud, now forming an unstratified mass of clay. As it is barely possible that the excavation extended downward in deep water to a considerable depth to any of the lower or older seams, we may perhaps infer that the bowlder came from the Straitsville seam at that spot. The direction—a little east of north—is the one in which the waters of the ocean of that period would be most likely to carry debris shoreward. We have, then, the apparent proof that the vegetation became hard and perfect coal after its burial in time to furnish bowlders now found in the coarse sand rock only thirteen feet above it. In other words, the time for the accumulation of twelve feet of shales added to whatever interval there might have been before the incoming of the sand, was long enough for the perfecting of the coal. This time is very indefinite, of course, but measured by stratigraphical accumulations, somewhat after the manner of Prof. Dana's time-ratios, it is geologically very short. In Wayne county, West Virginia, I found near the bottom of a very coarse sand-rock, and separated by about ten feet of bituminous shales, upon a thin seam of coal, quite a mass of angular fragments of coal. Some of the fragments were worn the merest trifle, but most were angular and some were sharply wedge-shaped. It is impossible to believe that fragments of so tender a material could have been subjected to the attrition of the coarse sand, with which they were transported, and in which they are now imbedded, for any considerable distance. Hence they were torn from some seam of coal not far away. It is, moreover, unreasonable to suppose that the cavity of excavation could have extended far down to the lowest and oldest coals, from the fact stated in the other case, that the work of such excavation must have taken place below the surface of the water, the last formed seam being at the time at least ten or twelve feet below that surface. If the coal came from the seam first below, it is reasonable to infer that the vegetation of the seam had passed through the process of bituminization and final solidification during the interval between the time of

the burial by sediments of the coal-marsh and the filling in of ten or twelve feet of intervening materials. The only other possible explanation of these facts, occurring to my mind, is, that some portion of the area of the lower Coal Measures had been raised above its proper place beneath the waters, and either constituted headlands from which the waters of the ocean could tear away the fragments of coal and transport them to their present location, or formed highlands from which rivers might have brought down the coal debris. So far as my observations go, there is not a shadow of proof of any such upheaval during the progress of the formation of our coal seams, but, on the other hand, all observed facts militate against such a supposition.

I have observed another class of facts which have interested me much, and which may have a bearing upon the comparatively rapid bituminization and solidification of the coal. Over considerable horizontal areas I have sometimes found the coal planed off as if it had already become a solid substance. For example, on Sunday Creek, Perry county, Ohio, I find the thick, or eleven feet, seam of coal—the Nelsonville or Straitsville seam—eroded in various places and in varying depths from the top. Sometimes it is planed or ground away to the depth of a foot; sometimes the whole upper bench is gone, and again the erosion has taken away the upper and part of the middle benches. Then several benches are always seen in great distinctness in the seam in its normal development, being separated by the partings of slate. In all cases the sandrock fills the space once occupied by the coal, and rests unconformably upon the eroded edges of the laminæ of the coal. The usual cover of the coal is shales, sometimes twenty feet or more thick, and there is every reason to believe that such shales were first deposited over the coal at the eroded places. At some subsequent time and after the vegetation had become coal, currents of water carried away the softer shales and perhaps, by the aid of moving sand, planed off the upper portion of the coal-seam. This has been done in a smooth and even manner, and there are no traces of the kind of rough work which the same force would have performed if the material acted on was a mass of soft and unconsolidated decomposed vegetable matter. In another coal-seam which I traced for miles in West Virginia, the upper part of the original seam had almost everywhere been planed off by a force which left over the coal coarse sand, now hardened into sandrock. In some places I found the remnants of the original top of the seam with shale over them. It appeared evident that the sandrock was not the first cover of the coal vegetation. No plants or fragments of trees such as often

show themselves in the roof of coal seams could anywhere be found in it. In the concavities in the under surface of the rock, I have found the coal which filled them preserving its horizontal lamination and not curved, or only slightly so, to fit the shape of the rock surface. Apparently the top of the coal seam, after it had become a comparatively solid body, had been removed, and the sand which covered it adjusted itself to the little irregularities of the surface of the coal. The interval between the time when the vegetable matter was first accumulated and the time when its first covering of shale was removed, and the sands brought in, might have been very great, but relatively to the time of the accumulation of the whole Coal Measures, it was very brief.

I have time, in conclusion, to notice only one or two matters of practical importance in the use of our bituminous coals. The vast quantity of excellent iron ore in our land, with a corresponding amount of excellent fuel for smelting it, points to this country as one destined to become the leading nation in iron manufactures. In this industry our bituminous coals are already beginning to play an important part. The prerequisites for a good furnace coal are—if we use the raw or uncoked coal—a dry or open burning quality, little sulphur, small ash, sufficient fixed carbon and firmness of coke. If coke and not raw coal be used, it should be firm and capable of resisting pressure, and contain as small per centage of sulphur and ash as possible. Sulphur in coal is a prime difficulty, but this is becoming better and better understood by iron manufacturers. Of late years attempts have been made with greater or less success, to separate the sulphur from coal by a somewhat mechanical process, viz., by crushing the coal and floating off by water the lighter and purer portions, which are saved and afterward converted into coke. The rest, composed of the coal charged heavily with bi-sulphide of iron and of the slate, is thrown away. When, however, the sulphur is not combined with iron as a bi-sulphide, but is in other combinations as has already been shown, this mechanical process must fail, and even when, as is often the case, the bi-sulphide is disseminated evenly through the whole mass of the coal, and is not in a segregated condition in the form of laminæ, discs, etc., there will also be a failure in the separation. The sulphur may be combined with the lightest and apparently purest portion of the coal, if quality is to be determined by specific gravity. For illustration, I give the analysis of a coal which appeared in every way promising, and contained no visible bi-sulphide of iron.

There was found by Prof. Wormley 0·39 per cent. of iron. This

iron would require 0·445 per cent. of sulphur to form the usual bisulphide. Besides this amount, there remained in the coal 2·885 per cent. of sulphur. This large amount of sulphur could not be removed by any washing process, since it is disseminated through the whole mass of the coal. If the purification of coal is therefore to be attempted by discriminating by a mechanical process, in the relative specific gravities, the method will only be successful where the sulphur is in the form of a bisulphide of iron, and this is in a segregated form.

Another important point to be determined in the use of bituminous coal for iron-making is the physical character of the coke. If raw coal is used, it is speedily converted into coke in the top of the furnace, and descends as such to the bottom, where it is consumed, and the chief heat produced; while in the bottom there rests upon it and upon the other materials which have descended with it the burden of the whole vertical column of the contents of the furnace directly above. The coke, therefore, should be firm and solid to hold up the superincumbent mass. If it is, on the other hand, tender and crushes under the weight, it becomes compacted together, the blast does not penetrate it, and a slow and imperfect combustion is the result. From such impeded combustion many and great evils arise which are familiar to all intelligent iron masters. To this cause, more than to any other, is to be attributed the "bad working" of so many furnaces using tender fuels. The firmest cokes are made from the more highly bituminous or coking coals, such as melt and swell when heated, and after the bituminous gases are driven off, leave a hard, porous, cinder-like mass, which has a metallic lustre and an almost metallic ring when struck. Such coke, either cold or hot, is broken with difficulty, and will resist great pressure without crushing. The best known English coke of this type is made from the North Durham coal. It is the strength and firmness of this coke that renders the very high furnaces of the Cleveland Iron District possible. The coke made from a similar highly cementing coal at Connelsville, Pa., has a somewhat similar firm and obdurate quality. All cokes made from the soft and caking coals have a tendency to be more or less firm from the fact that such coals soften and melt when heated. The best coke comes from the most thorough fusion of the coal. On the other hand, the dry and open burning coals show a very different behavior in the fire. They do not melt and swell, and consequently change but slightly their original form. A block of such coal parts with its bituminous gases through cracks, which more generally open along the planes of

lamination. The resulting coke is closer in texture, with smaller cellular spaces, is darker in color and less coherent. The closeness of texture, as compared with the more open character of the cokes made from caking coals, added to their brittleness, makes the cokes of the dryer coals less fitted to be permeated by the blast and less able to sustain the pressure at the bottom of the furnace stack. Of course, some of the cokes of each class are much firmer than others. Often iron masters using dry coals in the raw state, finding that they do not obtain sufficient heat, resort to the use of a certain proportion of firm coke. The difficulty is not, I think, in the heating power of the raw coal—for its coke may have quite as much fixed carbon as the other coke used—but in the simple fact that, in the first instance, the fire is partially smothered by the compacted condition of the fuel, while in the other case, the weaker coke of the raw coal is reinforced by the stronger, and thus the whole mass of fuel is kept in better condition to be permeated by the blast. There are very great advantages in large and high furnaces, as has been practically shown in the Cleveland Iron District, England, and, theoretically, by J. Lowthian Bell, in his masterly papers in the *Journal of the Iron and Steel Institute.**

In the West, we have a vast supply of dry burning bituminous coals, more or less splint in character, of great purity and excellence, which can be obtained very cheaply. These coals must be used for iron making, and will be. But the character of each kind of coal must be carefully ascertained, and the nature of the cokes must also be carefully studied. No two coals are exactly alike, and it is not wise to copy blindly the forms of foreign furnaces which have succeeded under entirely different circumstances and conditions. If we use a comparatively tender fuel we can adopt the very high furnace only, when by some method of construction and internal arrangement we relieve the weight of the superincumbent mass as it presses upon the coke in the bottom of the furnace stack. Such a construction is not, I think, impossible.

Since writing the above article I learn that Bischof, in a recent edition, which I have not seen, abandons his theory of the origin of coal.

*It may be well for those of our American iron manufacturers who show so profound a contempt for science, to know that Mr. Bell is himself a most successful iron master. It is on record that he "blew in" two furnaces, and at the end of two years had made in them 78.000 tons of iron, and in all that time had not made a single ton of white iron.

Contents for February, 1873.

Illustrations—One Plate and Three Woodcuts.

EDITORIAL.

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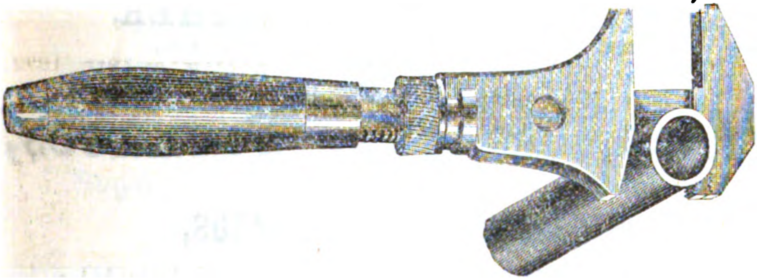

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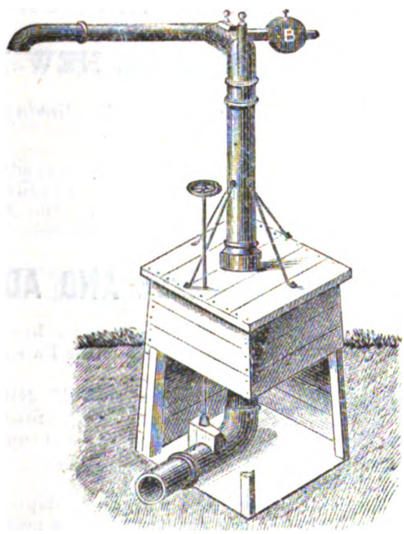

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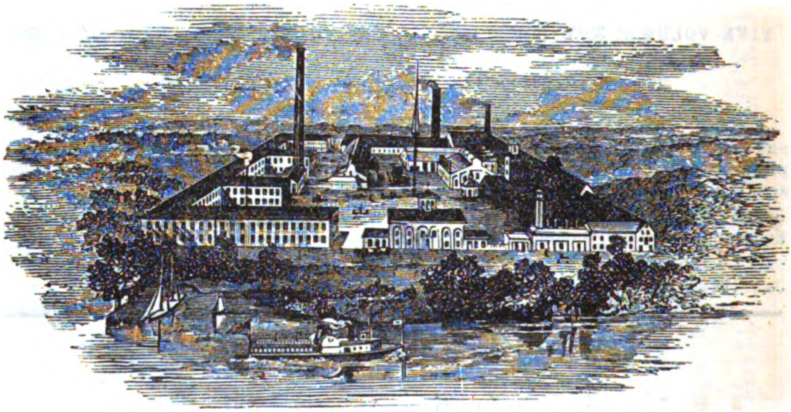

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FOR THE
PROMOTION OF THE MECHANIC ARTS.

VOL. LXV.] MARCH, 1873. No. 3

EDITORIAL.

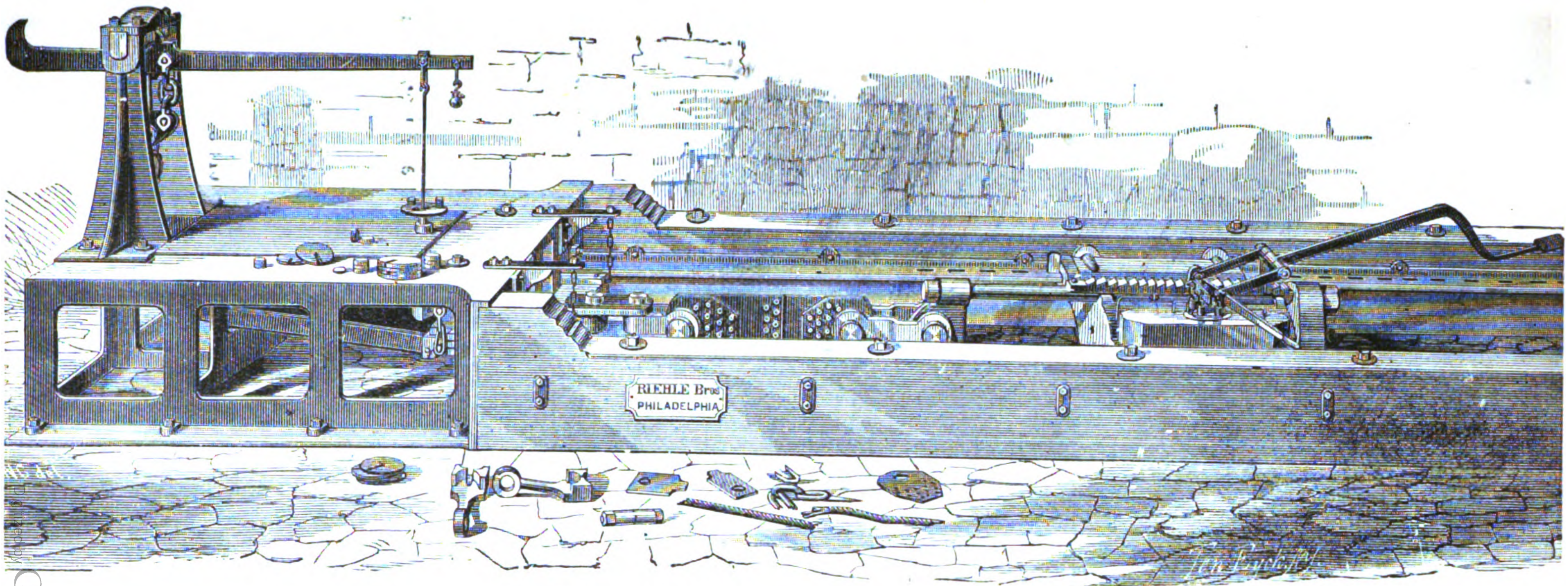
ITEMS AND NOVELTIES.

A New Testing Machine.—The accompanying engraving represents a new form of horizontal testing machine, of 75 tons capacity, built by Riehle Bros., Philadelphia, and designed by T. Alsen, Superintendent.

At one end, enclosed in an iron frame, is a heavy intermediate lever, one fulcrum of which (the upper one) bears against a plain steel surface composing a part of the iron frame, accurately and firmly inserted, the lower fulcrum presses against the clevis that connects directly with the tools that hold one end of the test specimens. This intermediate lever is suspended at the larger end by clevises that swing from the iron frame, and at the smaller end from a compound parallel crane beam that rests upon pedestals. Upon this parallel beam you will observe an ordinary weight-dish, upon which U. S. standard weights are placed to weigh the strain that the test piece is being subjected to; one pound on the weight-dish indicates a strain of one thousand pounds on the test specimen. At the other end of this machine is used a hydraulic jack and pump, which is placed upon low, strong wheels, and run along a railway and stopped at any desired

point by means of keys dropped into slots in the railway about ten inches apart; this is in order to accommodate the length of the test piece, which might be but a few inches, and can be a hundred feet long or more. The power is applied merely to take up the slack, the strain is weighed and even broken by the weights being placed upon the weight-dish on crane beam, which must be kept parallel by the use of the power and weights together. The equipoise of the beam is indicated by means of a finger point that must vibrate free when the proper weight is applied; this is clearly shown in the plate, between the pedestals. When the test piece is in position the lever and beam must be balanced by means of the balance cup hanging from extreme end of parallel beam. All the bearings and fulcrums are steel, made very strong and true, and as each part swings perfectly plumb, there is no friction, and a strain upon a specimen can be weighed to within a few pounds. The operation of the jack and pump is as follows: the handle of the pump being operated, the plunger of the jack is forced out horizontally, and is connected with the tools that are fastened to a cross head by means of two bolts. In order to get the plunger back again a lever is used that, being raised, catches in a ratchet, and when pressed down forces it back again; this operation also sends the fluid back from the jack into the pump reservoir. The iron frame and the timbers that support the iron guides are all firmly secured to a foundation of masonry. This machine is represented straining a piece of double riveted boiler plate (with ten rivets) in order to ascertain the comparative merits of steel and wrought-iron plates, also single and double rivets, with drilled and punched holes. It was built for E. B. Ward, Esq., Detroit, for the purpose of testing chain, wire and hemp ropes, also bridge bolts and boiler plate, and is ninety feet long when put up for use; but the construction of the machine embodies certain principles that can be modified indefinitely, and adjusted to apply any desired strain, to any material, in any shape or form—including the crushing resistance of iron or stone columns, transverse strain of girders, and torsional strain.

Rolling Molten Steel.—Our mechanical contemporaries have been commenting on a method recently invented by Mr. James Robinson, of Glasgow, for treating and shaping metals as they are poured in a molten state from a Bessemer converter or other vessel. The fluid mass is received between a set of rolls so placed as to retain the liquid metal until it becomes sufficiently chilled to be handled. The



RIEHLE BROS. TESTING MACHINE.

rolls at the receiving end are conically shaped, so that the iron is gradually compressed and a delivering action set up in the mass of iron as it passes between and longitudinally along the face of the rolls.

The advantages to be derived from a process with this object successfully accomplished would be numerous and noteworthy; but many difficulties are involved in the realization of the problem, chief amongst which consists in the necessity of keeping the rolls sufficiently cool as to prevent them from being warped by heat and pressure when working in direct and continued contact with a mass of metal at a temperature of about 2000° F. To obviate this difficulty the inventor proposes to cool the rolls, both internally and externally, by suitable methods.

Should the plan prove to realize the problem successfully, there will be nothing to prevent the production of steel bars of unlimited length directly from the converter, and at a considerably reduced price in view of the saving in cost of production from the avoidance of reheating for subsequent rolling; and it promises, in that case, to take the position of a radical innovation.

Improved Radial Drilling Machine.—The advantages of the radial drilling machine over the ordinary drill press, are becoming more fully understood and appreciated, and in the best machine-shop practice, it is acknowledged to be preferable to use the former on all work, no matter how small, while on work of any size, or which has several holes to be drilled in it, there is no question as to its great superiority. Heretofore, these machines have been used almost exclusively for drilling large work on the floor, and have not been adapted to work usually done on the ordinary drill press. Messrs. Thorne, De Haven & Co., of this city, have designed and are manufacturing a drilling machine, which possesses all the features of the most approved stationary machines, combined with the advantages of the radial machine.

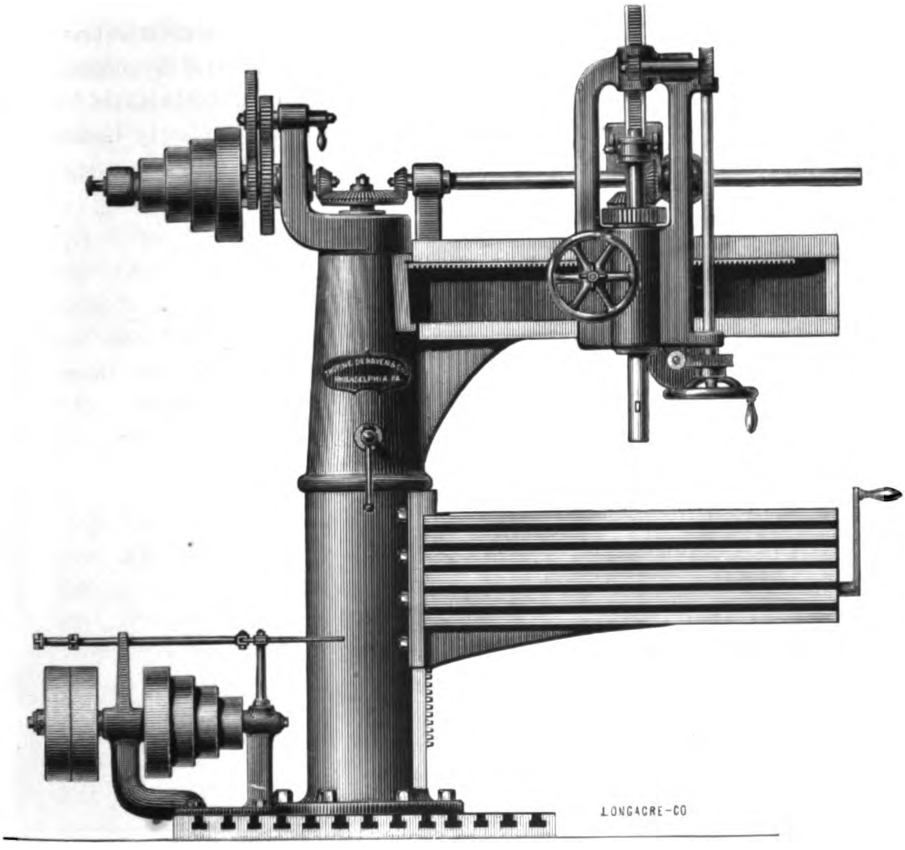
The counter-shaft is on the base-plate, and the driving cone-pulley and back-gearing on top of the post, thus placing the belt-shifter in a convenient position, and enabling the changes of speed to be made quickly. The bevel-gearing on top of the post permits the arm to rotate through an arc of 320 degrees, or eight-ninths of a revolution. The cone has four steps, which, with the back-gearing, gives eight changes of speed. The table has T slots on top and side, and

is raised and lowered on the post by a rack and pinion, operated by a tangent-wheel and worm. This enables the top of the piece to be kept at the same height. When the work is too high to go on the table at its lowest position, the base-plate which projects from the front of the machine can be used. The table being gibbed to the post, reduces the leverage, and makes a much stronger and stiffer arrangement than where it is set on a base-plate to depend for stiffness on a thin section of metal. The saddle carrying the spindle is travelled in and out on the arm by a rack and pinion operated by a hand-wheel in a convenient position. The spindle is counterbalanced by a weight, which is carried by the saddle—this being the only Radial Drill in the world which has this feature. As the counter-weight takes directly on the spindle, it prevents the latter from dropping, in event of any lost motion. This overcomes a fruitful cause of breaking drills; namely, when the drill drops into a blow-hole, or through a drilled hole before it is finished. The feed is obtained by a rack and pinion, operated by a worm and tangent-wheel—thus reducing the lost motion to a minimum. The self-acting feed has three speeds, and is connected and disconnected by a friction-clutch, operated in the centre of the hand-wheel. The hand-feed is quick, to enable the spindle to be run up speedily.

The Baltimore Tunnels.—The local journals recently contained an account of the two miles of tunnelling that is being constructed under the streets of Baltimore. The tunnels are broad enough to admit of the passage of two trains, with considerable leeway. The Potomac Railroad Tunnel, which is to unite the Baltimore and Potomac and the Western Maryland with the Northern Central Railroad, will be completed in all probability by the first of May. The Union Tunnel, which will connect the Philadelphia road with these, is also hastening to completion, and promises also to be finished by the same time.

The Southern bound passenger from the North will then, instead of going down to the President street depot, turn into the Union line, plunge underground at Bond street, on through the Union Tunnel, and out again into daylight, along the Jones' Falls valley up to the Northern Avenue Bridge, underground again, on out to Gilmer street, and thence southward along the Baltimore and Potomac line, having done in all a little more than two miles underground.

The Diagraph.—We have received from Messrs. Darling, Brown



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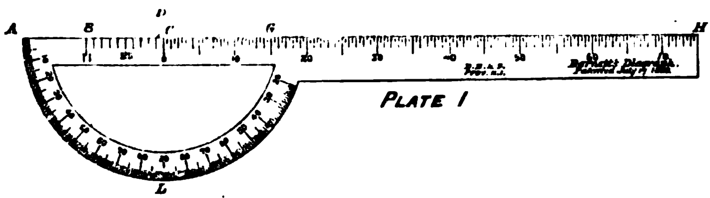
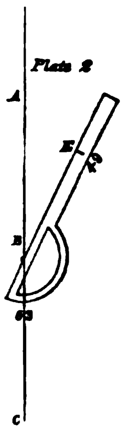
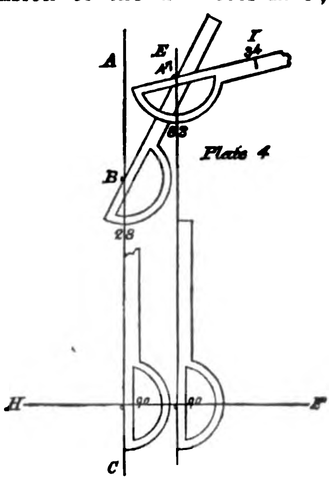


& Sharp, Providence, R. I., the description of an instrument to which they attach the above name, and for which they claim certain advantages. It is designed to substitute the ordinary box of surveyor's instruments, and the work of drawing diagrams and platting surveys is claimed to be greatly shortened by its use; and only requires the addition of compasses for circles to perform the work of the ordinary instruments with accuracy and facility.



The advantage of the instrument appears to be that it gives at one adjustment both the direction and the length of a given line. It consists of a slim circular protractor, A L G; four inches in diameter, graduated in degrees; of the rule A G H, the extension of the diameter A G, graduated into 10ths of an inch (and subdivided to show 20ths), a vernier C B, and a small nib or protection D. To most of our readers, who are familiar with the use of mathematical instruments, the use of the Diagraph will be obvious from an inspection of the engraving showing it. Figs. 2 and 4 are added to show its use respectively in drawing a line of desired length and angle, intersecting another, and in working up surveys from field notes.



East River Bridge.*—The work of preparing the grounds for the anchorage of the East River Bridge in James street, between Front and York streets, Brooklyn side, is progressing rapidly. A week ago the demolition of the thirteen buildings which occupied the ground required, was begun, and from present appearances it seems likely that the last stone will be taken away before the twenty days

* Chicago R. R. Review, Feb., 1873.

allowed for their removal have elapsed. When the buildings are all cleared away, guy-posts will be sunk to the number of ten in all, for the support of the stays, and a tower will be erected about mid-way between York and Front streets, 100 feet high, 114 feet broad, and 100 feet deep, over which the guys, which will support the main span, will be carried and brought down to a point at the corner of James and York streets, where they will be secured to bolts sunk in enormous anchor plates. Several other structures will be erected at intervals for the support of the Brooklyn side of the bridge, but there will be no other tower between the one on James street and the main tower at the river. It is probable the construction of the tower will be entered upon within two weeks.

Krupp's Establishment at Essen.*—In these gigantic workshops there were manufactured during the last year 150,000,000 lbs. of cast steel. In the year 1870 the product was 130,000.000 lbs. In this immense establishment 8810 workmen are employed, and engines with a total power of 9,595 H. P. are in requisition to operate the machinery. Amongst the various details of the works are included 528 furnaces for smelting, heating and converting, 169 forges, 260 welding and heating furnaces, 245 coke furnaces, 130 other furnaces, 342 turning lathes, 130 planing machines, 73 cutting machines, 172 boring machines, 94 grinding benches, 174 steam-boilers, 265 steam-engines, 58 steam-hammers, and 209 various other machines.

The products of these works consist of axles, wheels, rails, springs for railroads, steamship shafts, boiler plates, rollers, tool steel, rifled guns, &c. No other establishment in the world may compare with it in the extent of its operations.

The works are admirably managed, and the daily routine of operations goes on with the greatest regularity and precision.

Geological Survey in Pennsylvania.—The prospects for the speedy realization of this highly important work seems at present to be quite favorable. The fact that Pennsylvania, of all other States in the Union, more directly interested in securing a thorough and scientific knowledge of the character, extent and limits of her mineral resources—so intimately related to the prosperity of her vast mining and manufacturing industries—is not provided with a standing Geological Bureau, is an anomaly, which, in these days when the practical

* Am. Exch. and Review, xxii, 304.

value of scientific research is universally conceded, is anything but flattering to the profundity of her legislators.

Upon another page of the *Journal* will be found a letter written by Prof. Lesley, to the Governor of the State, in response to his request, in which will be found a lucid statement of the necessity and the value of such a survey, and also a plan for systematically conducting its operations.

At the last meeting of the Franklin Institute, the following resolution in reference to this important work was unanimously adopted:

Resolved, That the Franklin Institute heartily approves of the suggestions made by Prof. Lesley in his communication urging the establishment of a Geological Survey of the State of Pennsylvania, and fully appreciates the necessity and value of such a survey in advancing her material interests.

A Large Rolling-Mill.—The great rolling-mill at Bethlehem, Pa., now in process of completion, is stated, upon good authority,* to be the largest in the world. The main mill is 936 feet long, and 111 feet wide, the wings forming a cross 348 feet long. The whole structure is built, in the most substantial manner, of stone, iron and slate. The boilers are located outside the main works, the stacks being built of the most solid iron, riveted. They are 14 feet in diameter at the base, and are about 120 feet high.

Railway Speed in England.†—The average rate of speed on nine of the principal lines terminating at London, is 47¾ miles per hour. A train on the Great Western runs 76 miles at the rate of 53¼ miles per hour. The journey from London to Bath over this road is the quickest in the world. The distance is 106¾ miles; the train is timed for 2 hours and 13 minutes, including 10 minutes stoppage at Swindon; which makes the running time something over 53 miles per hour. The fastest time on the Great Eastern line is 41 miles per hour.

Utilization of Furnace Slag.—A method of utilizing blast furnace slag, so as to render it suitable for such purposes as ballasting for railways, &c., on the following plan, has been for some time in operation at the George-Marien furnaces, at Osnabrück, in Hanover, viz.: It is allowed to flow from a height of eight feet into water, the effect of which is to convert it into a pebbly condition. As rapidly

* Iron Age, Feb., 1873.

† Chicago Railway Review, Feb., 1873.

as this is formed it is taken from the water by means of an endless chain of buckets, which load it directly on the railway trucks.

Purifying Irons.—Experiments made with pig irons of poor quality at Thale-in-the-Hartz, by puddling them in contact with a small (1½) per ct. of fluor spar, with the view of removing the phosphorus therein contained, are stated to have been very successful. The product is stated to have been the production of a fibrous bar iron, not at all coldshort—a result which was somewhat remarkable, since the pig iron employed (Ilseder) is known to be amongst the poorest brands of German irons, containing a notable proportion of phosphorus.

Coal in China.—The presence of enormous coal beds in China seems to have been proven, by Richthofen and others, beyond doubt, and affords an interesting field for speculation as to the influence which possession of this civilizer must sooner or later exercise upon the future destiny of this exclusive nation.

According to the most accurate estimates thus far pronounced, the Chinese coal fields extend over an area of 400,000 square miles. In the province of Hunan there is a coal field of 21,000 square miles; consisting of two distinct beds, one of them being bituminous and the other anthracite. The last named of these is readily available, conveniently located for transportation by water, and equals in area the anthracite fields of Pennsylvania. In quality it is stated to compare favorably with the best anthracite known. Another province (Shausi), the coal area reaches the enormous figure of 31,000 square miles, and at the present rate of consumption could itself supply the world for thousands of years. The veins are from 12 to 30 feet in thickness, and are most favorably located for mining. Besides these highly favorable natural facilities, the province is stated to possess, in immediate proximity to the coal beds, exhaustless supplies of iron ore.

Experiments on Building Materials.—Some interesting experiments upon the influence which the acids existing in the atmospheres of cities exert upon building stone of various kinds, have been recently made by Dr. Angus Smith. This deteriorating influence was found to be particularly noticeable in cities using bituminous coal largely for domestic and industrial purposes. It was found that even the most siliceous stone was seriously affected.

The experiments were suggested by an observation of the rapid

decay of these materials as displayed in many English cities. The obvious inference as to its cause being that it was due to the action of the acids absorbed in the rain-water, the author was led to test the behavior of a number of samples towards acids, with the following results:

Blocks of various stones, of the size of one cubic inch, were broken by permitting a hammer to fall upon them from a given distance, and recording the number of blows required to produce fraction.

The same material was next steeped for awhile in diluted sulphuric acid, and subjected then to the same test; the result being that some of the specimens gave way at once, while others withstood the test with varying degrees of deterioration from the original quality.

These experiments are only the beginning of a series on the subject, and they promise to furnish quite a valuable contribution to our knowledge.

A Stationary Ship Saloon.—The attention attracted by the proposition of Mr. Bessemer to relieve the cabins of steamships entirly from the rolling movement of the vessel by suspending the same upon a pivot, is doubtless familiar to all the readers of the Journal. This design of Mr. Bessemer's has now, however, a rival in a proposition for a floating cabin devised by Mr. Alexandrovski.

The construction is similar to that of Mr. B., but the cabin, instead of being attached to a pivot, floats in a kind of tank placed amidships, between the engines.

The invention has been tested in practice by the head of the Russian Naval Department, and is reported to have proved entirely satisfactory—all efforts to shake the cabin having proved fruitless—and the rolling motion of the vessel being completely counteracted.

The Waste of Fuel.—At a recent meeting of the English Institute of Mechanical Engineers, the President, Mr. Siemens, made the statement that from one-half to two-thirds of the coal mined in England was wasted or destroyed carelessly; and that, theoretically, the fuel consumed possesses more than ten times the capacity for iron-making or steam generation than is now realized from it in practice. In explanation of his remarks he further stated that sixty-eight pounds of coal is theoretically enough to bring a ton of iron to the welding heat, and more than enough to melt the same weight of cast-iron; while the actual amount consumed varied from ten to twelve,

and at times to thirty times as much, and in some instances to even more.

But, to prove that much better results are within realization, he added that within the last nine years the consumption of coal per indicated horse-power has been reduced to one-half in the marine engine, and that if the average marine engine consumption of nine years ago is compared with the best results attained at present, the improvement is still more striking; for nine years ago the average consumption of coal per hour per indicated horse-power was 4·5 pounds. Steamships now make long voyages with a consumption not exceeding 2·2 pounds, and more rarely 1·7 pound of coal for the same duty.

Prize for Steel.—The Council of the Society of Arts has resolved to award the gold medal of the Society to the manufacturer who shall produce and send to the London International Exhibition of 1873, the best collection of specimens of steel, suitable for general engineering purposes. The following conditions are stipulated.

(*a*). The specimens exhibited for competition must include a complete illustration of the applications of the varieties of steel submitted.

(*b*). Each manufacturer should send with his specimens a statement of the nature of the tests he has applied to each kind of steel exhibited, and give the results of such tests.

(*c*). The samples tested are to be exhibited together with duplicate samples, or portions of the same samples, in order that they may be submitted to the same tests, should the Council deem it desirable.

(*d*). The Council reserve to themselves the right of withholding the premium in the event of the specimens exhibited not being sufficiently meritorious.

The Tin Discoveries.—In the last number of the Journal there was published a brief statement of the fact that extensive deposits of tin ore had been found in Queensland, and since that time a substantiation of the announcement has been made in the form of a report from Mr. T. V. Gregory, the mineral land commissioner of the Colony, which, besides giving much definite information as to the extent of the tin fields, places the value of the reputed discoveries beyond doubt.

From the report in question, we gather that the extent of territory upon which tin has been actually discovered, comprises about 550 square miles. Of this area, however, only about 220 square miles have been found to contain tin in sufficient quantity to pay for work-

ing. The country, in its geological and physical features, is an elevated table land, intersected by numerous abrupt hills. This country is traversed by numerous streams, of which the Severn and its tributaries are of especial interest in this connection, since it is on the course of this river that the greatest portion of the mineral wealth has been found. The richest deposits of ore have been found in the stream beds and fluviatile flats bordering upon them; the payable ground varying from a few yards to five chains in width, occasionally broken by rocky bars; but even in these instances, large deposits are frequently lodged in the pockets and crevices between the granite boulders. The probable yield of ore from the alluvial workings alone is estimated by Mr. Gregory at about ten tons per lineal chain of the creek beds, though in some instances it will be considerably greater than this.

Of the existence of veins or lodes the report also gives assurance that several of considerable size have been located and claimed; though of the probable value of these as sources of future wealth, when the alluvial deposits have been exhausted, the author does not venture an opinion.

The reported tin discoveries in Queensland may therefore be set down as fully authenticated, and we may shortly look for brisk competition in the production and export of the metal derived from the colony.

Improvement in Bending Glass Tubes.—If the glass tube we desire to bend be filled with *sand*, and each end stopped to prevent its escape on heating over a Bunsen burner, it will be found that the tube may be quite doubled if desired, a perfect curve being produced. In this way we may promptly produce accurate bends of any desired size in tubes of any bore without any previous skill in glass-working. Obviously, the principle depends on a uniform distribution by the sand of the pressure exerted. A similar plan is resorted to by metal-workers in bending tubes of lead. A. H. Gallatin.

Laboratory Cooper Union.

Comparative Value of Explosives.—The universal employment of explosive agents in engineering operations, which in these times have assumed a magnitude heretofore undreamed of, has made it a matter of much practical interest and importance to determine the relative value of the various materials employed for that purpose. Perhaps the most reliable experiments in this field are those of Prof.

Abel, who, in order to determine this question, made use of the opportunity to test the relative value of gunpowder, gun-cotton and dynamite, in driving a railway tunnel through limestone rock, the conditions of their employment being (as near as such a thing is possible in practice) equal for the three explosives tested.

The results of the comparative trials are stated as follows:

In one week the tunnel was driven eight yards with gunpowder, fourteen yards with gun-cotton and fifteen yards with dynamite, the weight of the explosives employed being—of gunpowder 756 pounds, of gun-cotton 169 pounds and of dynamite 165 pounds. The number of blast-holes per yard was—gunpowder 31, gun-cotton 18 and dynamite 17, and the cost was—gunpowder $142, gun-cotton $83 and dynamite $77.

In commenting upon these results, so favorable for the dynamite, several of our scientific contemporaries express themselves with some severity in regard to the shortsightedness of the legislation by which the manufacture, sale and transportation of this material is surrounded; since it has proven itself to be, in practice at least, as safe as gun-cotton, and considerably more efficient as an explosive.

A New Experiment.—Mr. Elihu Thompson has made the observation that tin-foil, if wrapped about a few crystals of chlorate of potassa, can be made to detonate loudly upon being struck smartly with a hammer upon an anvil, or in a mortar. The phenomenon being precisely analogous to the well-known experiment of triturating sulphur and the chlorate. To the best of our knowledge, the observation that such metals as tin can be oxidized in this way, is a new one and worthy of notice.

Soluble Glass in the Arts.—The employment of this substance in the arts is rapidly extending, and it has become indispensable in many industrial branches. It seems to be specially well adapted to the production of cements. When intimately mixed with fine chalk, it is found that a hard cement will be formed in from six to eight hours. With powdered sulphide of antimony, a black mass is produced which is susceptible of taking a high polish, and possesses then a superb metallic lustre. Fine iron dust gives a grey-black mass of great hardness. Zinc dust gives a grey mass of much hardness, and having a metallic lustre. Zinc castings can be readily repaired by its aid.

Concerning Glycerin.—The manufacture of this important substance has of late, in view of its constantly extending importance in the arts, been greatly expanded. During the past year the production in this country reached 2,000,000 of pounds, of which one firm in Cincinnati manufactured one-half of this quantity. Upon the same subject, it may not be uninteresting to note that, in a communication addressed to the French Society of Civil Engineers, M. Austin has highly recommended the employment of this substance as an anti-incrustator in steam-boilers. Glycerin, which is soluble, in all proportions, in water, appears, according to M. Austin, to increase very notably the solubility of the lime salts, to which the evils of incrustations in boilers are mainly ascribable; indeed, according to the author, it really forms with them a soluble compound. When the lime salts accumulate to such an extent as to be no longer soluble in the glycerin present, they are deposited in the form of a gelatinous sediment, which does not adhere to the boiler surface. M. Austin recommends the employment of one pound of glycerin to every 300 or 400 pounds of coal burnt. From actual trials made with the material, it is declared in the communication that the employment of glycerin for this purpose, and in the manner above described, proved successful.

Fusion of Platinum.—M. Violette communicates the fact that he has succeeded in fusing platinum. The draught of the furnace employed was very powerful, and the Hessian crucibles employed for the purpose, though lined with plumbago, were partially fused. The results of the experiments are stated as follows: In a crucible of this kind, 50 grms. of platinum were placed, partly spongy and partly in fragments; and after an hour's stay in the furnace the crucible was withdrawn, and at the bottom there was found a perfectly melted button of platinum of the same weight.

Stalactitic Gelatinous Silica.—In experimenting at the Central High School with silicate of soda solution, it was found that when such solution is placed in a small porcelain capsule or other suitable vessel, and to it is added about an equal volume of concentrated sulphuric acid, taking care not to add it too suddenly, the silica deposited prevents the thorough mixing of the acid and silicate.

If, now, the vessel be inclined so as to allow the liquids to run as a stream from the vessel, the deposition of the silica takes place in the form of an icicle or stalactite depending from the lip of the capsule.

On close examination, it is found that the acid runs upon the outside of the stalactite, whilst the silicate flows down the centre, or *vice versa*, the mass growing by successive additions to the lower extremity. The experiment is at once both pleasing and instructive.

ELIHU THOMPSON.

Magnetic Storms and Solar Outbursts.—Prof. Airy, in a recent communication to *Nature*, presents another fact which points to a probable relationship of cause and effect between solar disturbances and magnetic storms. Prof. Airy, in his communication, refers to an unusually violent outburst upon the sun's limit, lasting nearly four hours, which was observed by him on the 7th of July last. Upon the same day a magnetic storm occurred, which was sufficiently well marked as to cause a perceptible disturbance of the magnetic apparatus. The storm lasted for two days, and was brought to a close on the second evening by the appearance of an aurora. Taking the view that a connection existed between these phenomena, and that the terrestrial storm was the earth's response to a grand solar disturbance, Prof. Airy remarks that the time required for the latter to make itself felt upon the earth, was two hours and twenty minutes, and supposing that Pater Secchi, whose observations of the occurrence are referred to, was fortunate enough to witness the outburst from its commencement.

The Westinghouse Air Brake.—This invention, which has proven so eminently satisfactory in this country, appears to be meeting in England with equal approval. One of the leading engineering periodicals of that country in speaking of it makes use of the following language:

"The Westinghouse air brake has been fitted upon a complete train of the Metropolitan District Railway, and is working with the admirable efficiency which characterizes the apparatus. Upon this line, and indeed upon all of our metropolitan railways, where stations are placed so closely together, where the stoppages are so brief and so frequent, and where so enormous a passenger traffic exists, the adoption of an efficient continuous brake becomes, if possible, of more importance than on ordinary lines of railroads, for it is essential that the trains should be under a complete control, and that they should be brought to rest without the shock, which is the common attendant upon all ordinary and on nearly all special brakes." Engineering. Feb., 1873.

The value of the Westinghouse brake, in every needful particular, is fully proved by the experimental train now running regularly upon the District Railway, and the comparison it affords, both in regard to quickness and ease of action, with every other brake which has been tried upon the line, is most favorable.

To repeat the results of the experimental trips recently made with the train would be simply to repeat the results of experiences gained on other lines and already recorded by us. It is sufficient to say, that at each station the train of eight carriages was brought to a state of rest in half its own length, by only a partial application of the brake, the ordinary working speed never requiring the full power to be exerted.

In another paragraph the correctness of the principle which Mr. Westinghouse has adopted is thus recognized: "To bring a train from a state of rapid motion to one of rest, in the shortest possible time, is not the only duty of an efficient brake. This work may be performed, doubtless, by non-continuous brakes satisfactorily, so far as time is concerned; but there are other considerations—the passengers, the permanent way and the rolling stock—and it is only by dividing the work to be done, over as many wheels as possible, and by applying the pressure instantaneously and equally upon each, that a maximum amount of work is produced with the least possible wear upon rails or vehicles."

Iron in Missouri.—Some interesting statistical information is contained in a report upon the iron deposits of Missouri, recently published by Prof. Waterhouse. The report refers especially to the more remarkable iron localities, namely, Shepherd Mountain, Pilot Knob and the Iron Mountain.

Shepherd Mountain is about 600 feet high. Pilot Knob rises to an altitude of 1,114 feet above the Mississippi River. Its base, 381 feet from the summit, embraces 300 acres. The upper section of 141 feet is estimated to contain 14,000,000 tons of ore. Iron Mountain rises to a height of 228 feet, the area of its base being 500 acres. The solid contents of the cone have been computed to amount to 230,000,000 tons. It is thought that every foot below the surface will yield 3,000,000 tons of ore.

Artesian borings have been made and a depth of 150 feet below the surface at the base has been reached. The augur was still in ore, thus revealing a great persistence in depth, which perhaps is immeasurable. Prof. Waterhouse expresses the opinion that these moun

tains contain ore enough above the surface to supply 1,000,000 tons per annum for 200 years.

Another Steel Process.—A communication upon a method of making steel has lately been made to the French Academy, by MM. Bajoult and Roche. It is based upon the plan of partially decarburizing cast-iron by contact with a rich oxide of iron. The plan is not a new one in principle, and has frequently been the subject of trial, but the damaging influence exerted by the material upon the crucible has hitherto been a great drawback to the success of any such process. This objection the inventors above named claim to have removed.

The cast-iron and powdered ore are placed in metallic moulds, and are brought to a red heat in special furnaces. The re-action follows, and fusion only takes place after their transformation. Ingots are thus obtained, which are melted in the crucible, or on the hearth of the reverberatory furnace.

Ozonized Water.—A firm is at present engaged, in Berlin, in manufacturing ozonized water for medicinal purposes. From the prevailing opinion, which is not altogether without scientific probability, that the sanitary effects of sea air are to be ascribed to its relatively great proportion of ozone, the enterprise of the manufacturers will most likely be rewarded by a considerable demand for the substitute they claim to offer.

Cold as a Food Preserver.—M. Boussingault recently mentioned the fact that a number of samples of soup, meats, &c., which had been kept since 1865 in closed vessels at a temperature of 20°, retained all of their original qualities. The author also mentioned that the same fact was true of the juice of the sugar cane kept in a similar manner.

Slate Roofing.—An item has been extensively circulated concerning the advantage of bedding roofing slate in hydraulic cement, over the usual method of nailing them on dry, which leaves them subject to be rattled by the wind, and to be readily broken by accidental pressure. The cement soon sets, and the roof becomes like a solid wall. The additional cost of the plan is 10—15 per cent., but this, in virtue of the increased permanency claimed for the new plan, may really place a saving to its credit, in addition to which the greater security it affords against fire is a point in its favor.

Civil and Mechanical Engineering.

HYDRAULICS OF RIVERS.

By Bvt. Brig. Gen. Henry L. Abbot, Major Corps of Engineers.

Several months before the appearance of the recent series of articles upon the "Flow of Water in Rivers and Canals," contributed to the journal by Mr. D. F. Henry, it became my official duty to criticise three annual reports submitted by that gentleman to the officer in charge of the Survey of the North-western Lakes—whose assistant he then was—upon certain gaugings of the connecting rivers, made in the years 1867, 1868 and 1869. Those three annual reports furnished the groundwork for the articles in the journal, which contain some views not generally admitted by hydraulic engineers.

My reviews being easily accessible (*vide* appendices B B and B B 1, Report of Chief of Engineers, accompanying the annual report of the Secretary of War for the fiscal year ending June 30, 1870), and neither leisure or inclination favoring controversial writing on my part, the subject would not have been farther discussed, had it not been that Mr. Henry, in his recent articles, has fallen into serious misapprehensions, which call for correction, when referring to the "Report upon the Physics and Hydraulics of the Mississippi River," prepared by General Humphreys and myself. To correct those errors intelligibly, it will be necessary to state the problem presented to General Humphreys, when, in 1850, he undertook the investigation.

The low lands bordering upon the Mississippi are below the level of its floods, from near the mouth of the Ohio to the Gulf. The surplus waters accordingly poured over the natural banks, and swept through the swamps until they encountered upland ridges, which turned them back only to again leave the channel, and thus to pursue their course to the Gulf. The whole country, in its natural state, in times of flood, was thus a vast shallow lake, many miles in width. But this lake, when the floods had passed, and the waters had drained back to the channel, became a belt of alluvial land, of untold fertility and value. To reclaim it, was to win an empire from Nature. The work was begun in 1717, near the mouth of the river, by extending levees up stream. In 1850, the embankments, although quite inade-

quate, reached the vicinity of the mouth of the Arkansas, but above that point the river held undisputed possession. At that date Congress donated the swamp lands within their borders to the several river States, to provide a fund for reclaiming them, and the work was vigorously begun. But what would be the effect of this sudden and great change in the regimen of the upper river, upon the height of the floods in the cultivated region below? and, indeed, how could the upper region itself be most economically protected? This was the problem confided to General Humphreys, and upon which ten years of systematic and exhausting labor was bestowed. No small part of the difficulty was due to the fact that the science of river hydraulics was in its infancy, as the numerous citations from standard writers contained in chapter iii of the report sufficiently proves.

One cause of many of Mr. Henry's misapprehensions of the report is that he has failed to appreciate the internal evidence of the truth of its isolated conclusions, derived from the multiplicity of its checks and counterchecks. For instance: one of the problems was, to decide how much given additions to the discharge throughout the valley (known, but varying at different localities) would locally raise the water level—a problem never before attacked in a manner claiming to be even approximately scientific. To solve it, was virtually to construct a tower, each stone of which should be an hydraulic fact, established by direct observation and measurement. This was successfully done, as has been shown by subsequent observations, both by ourselves and by others; as, for instance, by the present Chief Engineer of Louisiana, Gen. M. Jeff. Thompson, who, in his report, dated December 15, 1871, says: "The facts granted in the work of Generals Humphreys and Abbot, on page 418, that an outlet of 100,000 cubic feet per second, at or near Providence, would reduce the flood level some five feet down to near Red River, has been most closely confirmed." The stability of a building carries evidence of the security of its foundations, and yet Mr. Henry attacks certain fundamental propositions, as if the evidence of their truth rested wholly on the original direct observations, and had not been abundantly verified by the correctness, experimentally proven, of numberless conclusions, both general and particular, based upon them.

But to consider his criticisms a little more in detail, and in the order in which he makes them.

He asserts that the double float which we used "had been previously tried by Mr. Charles Ellet, jr., on the same river." A little examination of the reports would have shown that the Survey had

been systematically using this float more than two months before Mr. Ellet's first trial.

He proceeds to state that "it would seem to be impossible" to read and record the angles and time while a fast float was passing through 200 feet. It would be prudent before venturing such an assertion to inspect the diagrams of our work, now deposited in the archives of the Engineer Department at Washington, and open to the inspection of any engineer. They exhibit the paths of thousands of floats, two points of each of which were fixed by triangulation, and establish by the parallelism of these paths and the accordance of the times of transit, the accuracy of the method. Long habituated to the details of exact trigonometrical surveying, Mr. Henry under-estimates the practical precision that can be secured by less elaborate field-work, and forgets that, in operating upon a moving mass of water, we may advantageously imitate the sportsman, who, in analogous circumstances, sacrifices the precision of the rifle for the superior celerity of the shot-gun.

The next point for consideration relates to Mr. Henry's own work. He gives, on page 323, a table of comparisons between the result obtained by floats and a meter at different depths below the surface, and deduces a normal difference between their indications. He states that the observations were made in the St. Clair river, "where it was over 50 feet deep;" but, by reference to the detailed tables of his official report, it will be seen that the depth, although not always mentioned, is there shown to vary between 29 and 49 feet, and that, in grouping the floats, he has considered only the depth below the surface, quite ignoring this important variation in depth of water. Moreover, although the data are the same, the column indicating "corrected difference" appears more unfavorable for the floats in his recent article than in his official report. But this question of the relative value of float and meter observations having been discussed at length in my official review, will not be considered here.

Mr. Henry proceeds to write: "In the Mississippi, the new theories of flowing water place the maximum velocity three-tenths of the depth below the surface. As these observations are the only ones which do not conform to the general law, it will be well to examine them."

This language contains several errors. Theory had nothing to do with the location of the fillet endued with the maximum velocity. Our observations established that, in any vertical plane parallel to the current, its locus varied greatly with the wind; but that, in calm

weather, it was usually below the surface. Upon these and other observed facts the new theory was based, but no part of this theory assigns any definite depth for this locus. Upon the Mississippi in still weather it is usually at three-tenths of the depth below the surface; on some other streams we found it to be higher. No general law was announced, nor is such a law of any great practical importance, because in the general formulæ for discharge the quantity disappears by cancellation. As to our observations being the "only ones" which do not conform to the Darcy-Bazin results in little canals, Mr. Henry is greatly in error. The examples he cites (all of which are quoted in the Mississippi Report) do not comprise the "only ones" ever made, nor, indeed, do they all conform to the so-called "general law." Observations upon the Po, the Chiese, the Arno, the Rhine, the Waal, the upper Mississippi, and other streams, unite with ours taken upon the Mississippi and its bayous, to disprove the general character of this "law."

Mr. Henry next devotes a couple of pages (p. 384—6) to attempting to throw discredit upon the conclusions we derived from our field data. The simple facts, which refute all his inferences, were these: Two objects were in view—to gauge the daily discharge, and to determine the law governing the action of cohesion among the fluid particles. The former required daily measurements extended quite across the river; the latter, exact and greatly multiplied observations in single vertical planes parallel to the current. In each case, the path of every float was accurately located by careful triangulation where it crossed each line, and nothing was "assumed." The intended use was made of every float observed, exactly as stated in the Report, and no other use could properly be made of it, although the observations were all entirely "reliable" for solving the problem for which they were designed.

Mr. Henry's attempted tabular exhibit of our results (p. 386) is fundamentally erroneous. No such simple analysis is possible; for the reason that all individual curves of observation contain anomalies, which must be eliminated by the cancellation resulting from the multiplication of data, before they can be discussed in detail. Until a curve is thus obtained which conforms closely to the law of continuity, only a general discussion is admissible. It is therefore hardly ever practicable to fix upon the exact locus of the true maximum velocity in a curve based upon a few observations; and this can never be done by Mr. Henry's method, of taking for the maximum the greatest velocity actually observed, without regarding the relative velocities

of other floats in the vicinity. But, even if this method of discussion were not entirely inadmissible, his proposal to reject about three-eighths of the whole data, for no better reason than that it "must certainly be erroneous," hardly accords with usual scientific rules.

As to the statement, twice repeated, that "one of the verticals in the first series gives the maximum at the bottom, or rather one foot below the bottom, as recorded," it need only be said that no observations were made at the bottom or below it, neither were any so reported. The true meaning of the record referred to is so evident upon inspection of the original text that it is quite needless to explain it here.

The next subject inviting attention is the form of sub-surface velocity curves as discussed by Mr. Henry. He gives (page 30—1, vol. lxiii) several mean curves deduced from his Lake Survey observations. Before accepting these data, reference should be made to the detailed tables contained in his official reports, whence they are derived. An inspection of these tables reveals a mathematical solecism which deprives the published means of all claims to exactness, viz., that interpolation is wholly ignored. To defend this singular method, Mr. Henry makes use of the following language: "If there are but few observations missing in a large number taken, then it will make but little difference whether we interpolate or not, for it will make but a slight variation in the mean; but if the missing observations are numerous, then (as they must be interpolated either in a straight line drawn between the known points, or in a curve) the mean will approximate more or less to the line or curve by which the interpolations were made."

The fallacy of this reasoning is best illustrated by an example taken from one of his own detailed tables, giving the subsurface velocities in the Niagara river, as observed in 1868.

Observed Velocity of River at the following Depths.

Date.	20	25	30	35
July 22d,	2·730			2·789
27th,	4·680	4·412	4·119	3·969
29th,	4·551	4·220	3·857	3·676
Means as published,	3·987	4.316	3·983	3·478
True means,	3·987	3·794	3·582	3·478
Mr. Henry's error,		0·522	0·401	

A simple diagram will make the error of such a method of grouping observations apparent to the eye, and will show that before any well-grounded opinion as to the form of curve indicated by Mr. Henry's observations can be formed, an entire recomputation of his published means is necessary.

He proceeds to test by two of these supposed mean curves, the various forms proposed by hydraulic engineers—among others the "parabola of Humphreys and Abbot," which he concludes to be the "worst form" of all. This adverse opinion is due to his assuming an unwarranted value for the depth of axis, as may easily be shown. Since his own figures indicate that our parabola, when applied to his supposed mean curve for the St. Lawrence, has a maximum discrepancy of only 0·058 ft., and a mean discrepancy of only 0·022 ft. per second, it would be a waste of time to see if the accordance is not really more close. For the St. Clair river, however, his error of applying the formula is more serious, and calls for correction. In so doing, the surface velocity is neglected, since he frankly admits that it is "not properly taken."

St. Clair River—Depth from 44 *to* 47 *feet.*

Depth of Obs.	Observed velocities per second.	Humphreys and Abbot parabola as computed by Mr. Henry.		Humphreys and Abbot parabola correctly computed.	
		Curve.	Difference.	Curve.	Difference.
	3·868	3·564	—0·304	3·990	
5	3·907	3·573	—0·334	3·907	+0·000
10	3·821	3·564	—0·257	3·804	+0·017
15	3·709	3·536	—0·173	3·683	+0·026
20	3·608	3·489	—0·129	3·543	+0·065
25	3·496	3·423	—0·073	3·384	+0·112
30	3·309	3·339	+0·030	3·206	+0·103
35	3·100	3·237	+0·137	3·010	+0·090
40	2·678	3·115	+0·437	2·794	—0·116
42·4	2·388	3·050	+0·662	2·684	—0·296
45·4	1·428	2·962			
Sums,	33·884		2·536		0·825

One important fact is not to be forgotten in any comparison of these several proposed forms of curve. Other engineers simply give

a general form, leaving such valves of the constants to be selected, in each individual case, as shall cause the best possible accordance between the theoretical and observed velocities. In our parabola, a general equation for the parameter, depending upon the mean velocity and depth, is given; and the form of the curve is, thererefore, definitely fixed. Bearing this in mind, it is considered that the comparison instituted by Mr. Henry, freed from his errors of misapprehension, shows our curve to be fully equal to any of the rest, even as tested by these uncertain means.

Mr. Henry concludes by regretting that we did not select an ellipse, instead of a parabola, as most nearly indicating the law of variation. This was not done, because our ample data did not so indicate the law. But even if it had been found that an ellipse would give a slightly closer accordance with observations than a parabola, that curve would not have been selected, because we had to make a practical use of it in framing new formulæ for the discussion of higher branches of the subject of river physics; and the areas bounded by parts of an ellipse form a complicated series, while those bounded by parts of a parabola may be expressed in terms of a simple rectangle. This advantage would have been decisive, even if we had found (which we did not) that an ellipse would accord more closely with observation than a parabola, by a few thousandths of a foot of velocity per second.

But the truth of the Humphreys-Abbot theory for this curve does not, at this date, rest simply upon the Mississippi observations. The matter has been carefully studied since—among others by von Heinr. Grebenau, who has submitted thirteen old sets of observations, made by Zendrini, Lecchi, Lorgna, Zimenes, and Brüning, and not accessible to us, to careful analysis, with the following conclusion: "It is remarkable that the law of decrease" (our parabolic law), "which is obvious in all of these earlier experiments, could have remained so long unknown." He also made some careful measurements himself on the Queichbach, near Germersheim, which not only confirmed our parabolic law, but also verified our general equation for the parameter of the curve. Other observations of similar character might be named.

In his remarks upon the mean velocity of rivers, among other errors relating to the Mississippi Report, Mr. Henry has given a partial extract from a paper written by me for the Essayons Club of the Corps of Engineers, which wrongly conveys the impression that the

new data published in the work of Darcy and Bazin did not confirm our formula. In reality, I showed that they verified it in the most complete manner, and even afforded authority for extending its use to a class of small natural streams, with great slopes, to which it was not claimed to be applicable in the Mississippi Report. The valuable work of MM. Darcy and Bazin extended the table of trustworthy observations upon natural channels to a total number of seventy-three, only four-tenths of which were to be had in framing our formula; yet its average percentage of error is only six per cent., or about that of careful actual measurement. Our formula was based upon every observation we could procure, of an exact character, published either in this country or in Europe; and no "selection," except upon grounds which were fully explained, was made. That good judgment in this respect was used is sufficiently shown by these new Darcy-Bazin data.

Mr. Henry also gratuitously infers a "disagreement" in our Mississippi levels, which had no existence in fact.

In giving the results of his own slope measurement on the St. Clair river, and applying the several formulæ to them, he does not state —what his official reports show to be the fact—that the discharge was measured at widely different dates from the slopes, and hence, probably, bore no relation to them.

In proposing to substitute six-tenths of the depth for the mid-depth recommended by us as the uniform locus of velocity measurements for discharge, Mr. Henry has failed to appreciate that he would thus introduce a variable error due to wind effect. His own figures and computation show that our simple mid-depth method, when compared with his own laborious and costly operations, exacting observations at all depths, gave results differing only by seven-tenths of one per cent. in the discharge of the St. Clair, by two and seven-tenths per cent. in that of the Niagara, and by one-tenth of one per cent. in that of the St. Lawrence.

In now finally closing this dicussion, so far as I am concerned, I would cheerfully accord much credit to Mr. Henry for his ingenuity in the application of electricity to recording the revolutions of a submerged meter axle. In this he has made a real contribution to the accuracy of hydraulic measurements in wide harbors and tidal ways, where operations from the shore are hardly practicable.

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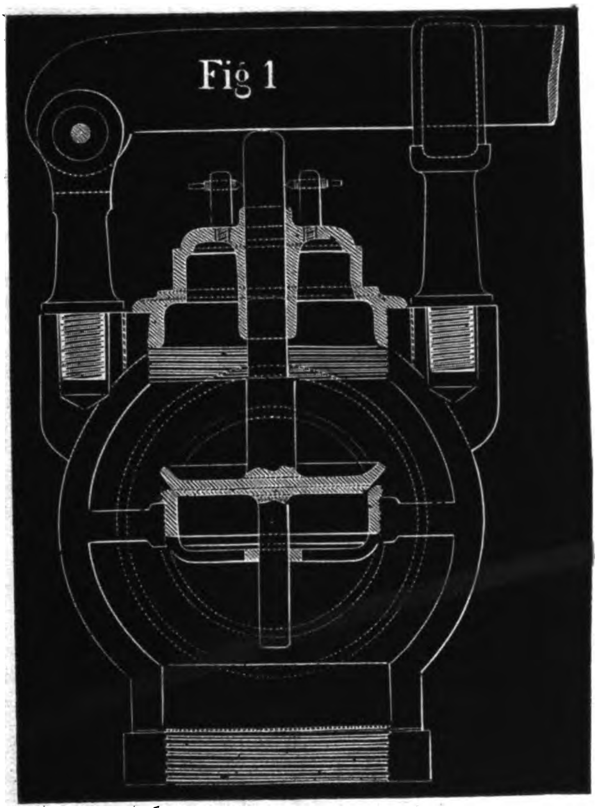

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THE NICKEL SEATED SAFETY VALVE.

CHIEF ENGINEER'S OFFICE,
WASHINGTON, *December 2d*, 1872.

Rear Admiral L. M. Goldsborough, U. S. N., Commandant.

SIR:—In obedience to your order of September 12th, 1872, to test the "Nickel Seated Safety Valve," manufactured by E. H. Ashcroft, of Boston, Mass., and report upon its advantages and disadvantages, I beg leave to submit the following:

The boiler used for the test was of the cylindrical horizontal tubular type, six feet in diameter, twenty feet long, grate surface twenty-two square feet, heating surface nine hundred and twenty-eight square feet, and of about thirty nominal horse-power. Pressure of steam used in the test from sixty-five to eighty pounds per square inch.

The experiments were comparative, and were made with seven valves, of the common kind, of the following diameters, viz.: 4″, 3″, $2\frac{9}{16}$″, 2″, $1\frac{21}{32}$″, $1\frac{13}{32}$″, and 1″, and seven of the nickel seated valves, of diameters 4″, 3″, $2\frac{1}{2}$″, 2″, $1\frac{1}{2}$″, $1\frac{1}{4}$″ and 1″. The object was to ascertain the lift and area of opening given for the escape of steam when the valve was acting freely and blowing off at full pressure of steam, and to ascertain how much the pressure could be increased after the valve was in full operation. The lift was ascertained by securing scratchers against the valve stems. The results can be seen by referring to the accompanying diagrams. The outer circles represent the circumferences of the valves. The areas of the inner circles represent an area equal to that given for the escape of steam by the circumference and full lift of the valve when blowing off at the limit of pressure.

In these respects the nickel seated valve possesses an advantage which places it beyond comparison. The 4″ common valve, when blowing off at the limit of pressure, had a lift of $\frac{1}{20}$ of an inch, giving an area for the escape of steam of $\frac{63}{100}$ of a square inch. The nickel seated valve of the same diameter, operating with the same pressure, had a lift of $\frac{1}{4}$ of an inch, giving an area for the escape of steam of 3·14 square inches. The 3″ common valve had a lift of $\frac{1}{17}$ of an inch, giving an area of opening of $\frac{56}{100}$ of a square inch, while the 3″ nickel seated valve had a lift of $\frac{3}{16}$ of an inch, giving an area of opening of 1·76 square inches. In the experiment to ascertain how much the pressure could be increased while the valve was blowing off at the limit of pressure, with the 4″ common valve, which is about the diameter used on boilers of the size mentioned, the pressure was

increased five pounds in four minutes, without any apparent increase in the lift, and the experiment was stopped. With the 3″ valve the pressure was increased nine pounds in six minutes. The 4″ nickel seated valve operating under the same circumstances opened to its full lift as soon as the limit of pressure was reached, and the pressure could not be increased, but it steadily decreased to a point a little below the original pressure, when the valve suddenly closed. With the 3″ valve the pressure was held at the limit of pressure. In both cases the fires were in active condition and the furnace doors closed.

This experiment proved that the lift of the common valve is not sufficient, and will not increase with the pressure, by its own action, sufficiently to relieve the boiler under all circumstances, and that the pressure can be increased until an explosion takes place, while the valve is in operation, and therefore it is not, in reality, a safety valve.

The nickel seated valve, under the same conditions, obtained its full lift instantaneously by its own action, giving an opening of sufficient area to relieve the boiler at once.

The common safety valve needs no description. The nickel seated valve is automatic, and can be used either as a lock-up or an open valve. It is actuated in its resistance to the steam pressure by a spiral spring of the most accurate workmanship, and plated with nickel. The face of the valve coming in contact with the seat is composed of a solid ring of nickel. The valve seat is also of solid nickel. The qualities of this metal form one of the most important features in this valve. Its great hardness insures its resistance to wear. It is not affected by the action of steam and the saline matter in water, and, being non-corrosive, it is free from the possibility of sticking, as is often found to be the case with the common valve, by corrosion, and which may be attended with the most fearful consequences. The valve is constructed with a curved lip, as seen in the accompanying drawing, so that the main body of the steam, as it escapes from the boiler, being directed downward, strikes against the bottom of a suitable recess surrounding the valve seat, and the recoil of the steam acting upwards against the under surface of the valve as it issues into the atmosphere assists the valve in obtaining a higher lift. This action is sure and instantaneous, and it was found that the greater the steam pressure the higher the lift, using the same spring. For instance, with a 3″ valve, the spring being set to open at sixty pounds, the valve will lift full $\frac{1}{8}$ of an inch, and with the same spring set to open at eighty pounds, the lift will be $\frac{3}{16}$ of an inch. The lift of the common valve will remain the same at any pressure, the weight

on the lever being adjusted to the given pressure as in the case of the spring. For instance, if the weight is adjusted to yield to a pressure of twenty-five pounds, the lift of the valve will be about $\frac{1}{32}$ of an inch, and if adjusted to a pressure of eighty pounds, and raised by the steam, the lift will be the same.

The late experiments at Sandy Hook, N. J., on steam boiler explosions, have disposed of many old theories regarding this subject, such as electricity, formation of gases, the sudden generation of steam of an enormous pressure, &c., &c., and have proved that explosions of the most destructive character can occur by the gradual accumulation of steam and with the moderate pressure of fifty three and one half pounds per square inch.

It was also observed that it required but thirteen minutes to raise the pressure from thirty pounds, the working pressure allowed for this boiler, to fifty-three and one-half pounds, when it was torn into fragments, and a part of it, weighing three tons, was hurled four hundred and fifty feet from its original position, showing that the neglect of only a few minutes, together with an inoperative or inefficient safety valve, are all that are required to produce the most frightful results.

The subject of safety valves, heretofore so much neglected, is receiving considerable attention in England and elsewhere, and the experiments made with the common valve corroborate some of the above statements. Under whatever circumstances explosions may occur, the real cause is excessive pressure, and the fact that such disasters do occur, whether from neglect or otherwise, involving fearful loss of life and property, points forcibly to the necessity of providing against them in every possible way, and the only safeguard that can be applied to a steam boiler is a safety valve, that is automatic, certain in its action, prompt in opening and closing at the required moment, and that can be fully relied upon to relieve the boiler under all circumstances.

It is impossible to provide against the contingent dangers of a steam boiler, such as the hidden imperfections of the iron, the chemical action to which they are subjected, &c., but for the prevention of any pressure in excess of that allowed, I am fully of the opinion that the "Nickel Seated Valve" is the only one that fulfills the requirements.

Very respectfully your obedient servant,

EDWIN FITHIAN,

Chief Engineer, U. S. N.

REPORT ON BOILER INCRUSTATION.

HANNIBAL, MO., *May*, 1872.

To the American Railway Master Mechanics' Association:

GENTLEMEN,—The Committee to whom it was your pleasure to again refer the subject of Boiler Incrustations, their Causes and Cure, would respectfully report that they have given the matter as serious a consideration as the time and its great difficulties would permit.

In accordance with former practice, circulars of inquiry have been addressed for information to various parties, but to such only as might have something to offer, from investigations made since our last annual meeting. We regret that no new or important information has been elicited, throwing additional light upon the subject; your Committee being therefore unable to present any new facts, will have to confine itself to an allusion to the experiments which have been going on for the past two years, and also to speculation upon the relative cost of purifying water before it is taken into the boiler, if, indeed, such a thing can be accomplished at all. In justice to Mr. J. H. Setchel, who has written at considerable length on the subject, the Committee would suggest that his communication be read in full.

The use of pure water is universally recommended as being the only effectual remedy. Some, however, are still experimenting with fluids, powders, batteries, etc. It will be remembered that the plan, or a similar one, recommended last year by Mr. S. J. Hayes, of the Illinois Central Railroad, was indorsed by the Committee, and embodied in their report as the fundamental principle through which this great evil can only be effectually overcome. It is the opinion of your Committee that the impurities contained in water will precipitate sufficiently for practical purposes after a certain amount of boiling, but whether this method of purifying can be made practicable and cheap is a question which we cannot from our own experience determine. We are not prepared to believe that chemical means alone can be economically employed for the precipitation of the materials in water which form incrustations; but to this we shall again refer. A subject which has so long baffled the skill of the leading scientific and practical minds at home and abroad, cannot be properly treated without reaching in vain after the necessary data to make the article wholly reliable and conclusive. We think so great an evil as boiler incrustations, involving in its range violent explosions, loss of life, and great destruction of property, should have the combined effort of

scientific and practical men towards the development of a remedy; and to this your Committee, fully realizing the extreme difficulties of the subject, have invited the co-operation of eminent chemists and scientists, and from them they have not as yet obtained anything sufficiently definite to warrant its presentation, and hence they feel that the only way left open to them by which they can discharge their duty to themselves and the Association, who have honored them by their appointment for this particular office, is to present their own crude and imperfect ideas and experience for what they may be worth. It was thought that enough was said upon this subject last year to stimulate an interest on the part of railway companies in the manner of purifying water before using it in their engines, but we have failed to hear of any experiments in that direction.

Your Committee do not believe a remedy can be devised without more or less experimenting, all of which must necessarily be attended with considerable expense; but they will endeavor to show that at least some economy may be the result.

The plan which we shall attempt to explain is one which we believe will nearly if not quite purify the water before it is taken into the boiler, and it is yet hoped, by the introduction of chemical agents, that this method may be simplified and prove practicable and cheap. Not having tried any experiments in this direction ourselves, we shall be confined to the experience of others to prove our theory, and will first refer to a paper prepared as a report of experiments made by Professor C. F. Chandler, of Columbia College, New York, to the President and Directors of the New York Central Railroad Company upon the various kinds of water used by the locomotives of that Company along the line of that road, with an analysis of the waters, showing their composition, and also an analysis of the scale formation from such waters, and what chemical agents and processes would decompose and prevent the same. The report was read before the American Institute Polytechnic Association, January 11, 1866.

The following article appears in this report: "Boiling expels the free carbonic acid and causes the separation of the carbonates of lime and magnesia, and if conducted at a high temperature, under considerable pressure, results in the almost complete precipitation of the sulphate of lime. This would, however, merely transfer the incrustations from the locomotive boiler to some other vessel and would, therefore, be valueless in this case." This is just what we desire to do, transfer the incrustation from the locomotive boiler to some other

vessel provided to receive it and so arranged that the sediment may be removed at pleasure. Then supervenes a difficulty in the use of chemicals for precipitating the lime, etc., from the water, which seems to offer two insuperable objections. The first found is in the nature of the chemicals used; for, whilst precipitating the matter forming incrustations, they may corrode the metal itself. All chemicals would have to be used to purify the water before entering the boiler, in order to avoid this corrosion and also the precipitation into it, which would still demand cleansing of the foreign matter. Then a second objection arises out of the wide differences of water in the different sections; whilst incrustations are formed from those which contain lime, yet there may be and is such a difference of chemical admixtures as to render it wholly impossible to find any one universal chemical sufficient to dissolve these different elements. Hence we feel the necessity of looking somewhere else than to chemical solvents alone for a solution of the difficulty.

If Professor Chandler's theory be correct, an apparatus can be easily arranged at each water tank along the line of the road by which the water may be heated, and if desired subjected to a pressure, before being taken into the locomotive boilers. From his statement we may assume that the impurities in water will precipitate at a temperature of two hundred and twelve degrees; if this be true, the best and cheapest method of heating the water to this temperature, and its treatment after being so heated, only remains to be proven, and your Committee would suggest the following plan: Let each watering station on the line of the road be provided with a pumping engine or steam pump, with a capacity in proportion to the amount of water required. The exhaust steam from the pump should be conducted into a suitable heater, together with as much live steam as may be necessary to raise the water to a boiling heat. The heater being closed, the water within it at the boiling point would be subjected to a pressure of about fifteen pounds to the square inch. The heater should be made of iron, and as large, perhaps, as one-third the capacity of the tub. While the heater is being filled the water should be raised to the boiling point, after which the calcareous and other matter in suspension should be allowed time to settle, when the water can be drawn off into the tub arranged to receive it. After the heater is emptied the sediment may be blown off, and this process repeated until the tub is filled, thus keeping up the supply of purified water according to the demand.

The expense attending this apparatus would be equal to the cost of a No. 4 Knowles steam boiler and pumps complete—$450—together with the heater and its fixtures all told would not exceed $1000; and deducting from this amount the value of the present machinery employed, consisting of one ordinary horse-power and a four-inch hand or power pump, would make actual expense of first cost at such watering station about $800. The second cost, or continual expense, may be estimated in proportion to the amount of fuel consumed for the purpose of heating the water. Assuming as a basis that one pound of coal will evaporate eight pounds, or one gallon of water, we would only have to estimate the amount of coal consumed to arrive at the approximate consumption of water. It has been proven by experiment that if five and a half pounds of water, at a temperature of thirty-two degrees, be placed in a vessel communicating with another one in which water is kept constantly boiling at the temperature of two hundred and twelve degrees, until the former reaches the temperature of the latter quantity and is then weighed, it will be found to weigh six and one-half pounds, showing that one pound of water has been received in the form of steam, through the communication, and reconverted into water by the lower temperature in the other vessel. Now this pound of water received in the form of steam had, when in that form, a temperature of 212°. It is now converted into the liquid, and still retains the same temperature of 212°, but it has raised five and one-half pounds of water from this temperature of 32° to 212°, and this without losing any temperature of itself. It follows, then, that in returning to the liquid state it has parted with five and one-half times the number of degrees of temperature between 32° and 212°, which is equal to 180° and $180° \times 5\frac{1}{2}° = 990°$. Now this heat was combined with the steam, but as it is not sensible to a thermometer it is called latent heat. It is shown, then, that a pound of steam in passing from a liquid at 212° to steam at 212° receives as much heat as would be sufficient to raise it through 990 thermometric degrees, if that heat, instead of becoming latent heat, had been sensible, and $990° + 212° = 1202°$, being the whole amount of heat in steam. Hence it will be seen that one pound of coal, capable of evaporating eight pounds of water, will raise to the boiling point about five and one-half times as much, say forty-four pounds, or five and one-half gallons of water. To this must be added the relative value of the exhaust steam from the pumping engine, which will be equal to five and one-half times the amount of water evaporated in pounds.

Supposing, for example, that one locomotive running 2600 miles a month, or 31,200 miles a year, will make 45 miles to one ton of coal; it would then consume 693 tons of coal per year, at \$2.50=\$1732.50. If this locomotive will evaporate six pounds of water to one pound of coal, it will require 8,316,000 pounds, or 1,039,500 gallons of water. It is estimated that a No. 4 Knowles steam pump will raise 5940 gallons of water an hour. In doing this work it will consume about 60 pounds of coal, requiring 10,500 pounds to pump the whole amount of water. If the pumping engine will evaporate eight pounds of water to one pound of coal, the exhaust steam will boil about five and one-half times this amount, or forty-four pounds of water to one pound of coal, equal to $10{,}500 \times 44 = 462{,}000 \div 8 = 57{,}750$ gallons. This would leave 981,750 gallons to be boiled by the use of live steam from the boiler, which will require one pound of coal to five and one-half gallons of water, or $981{,}750 \div 5\frac{1}{2} = 178{,}500$ pounds coal $\div 2000$ 89 $\frac{25}{100}$ tons. This, added to the amount of coal required to pump the water, would make about 94 $\frac{50}{100}$ tons, at \$2.50=\$236.25, total expense for fuel in purifying the water in one engine for one year. Boiler repairs, including machinists' labor in taking down and setting up machinery that would not be otherwise done, would amount to about \$550 a year. Of this amount fully sixty-five per cent. may be due to incrustations alone. Judging from reports received by your Committee from Eastern and Southern roads using water, from which no incrustations form, where boilers run from fifteen to twenty-seven years without repairs, it may be safe to assume that even seventy-five per cent. will be saved by the use of pure water. But granting that only sixty-five per cent. is saved, the actual cost of boiler repairs due to incrustations would then be \$357.50.

We will now consider the extra amount of fuel necessary to heat the water through the increasing formation of incrustations, which we will attempt to illustrate as clearly as possible, from the best information we have been able to gather, from both theory and practice. Dr. Joseph G. Rogers, in a paper on steam boiler waters and incrustation before the American Association for the Advancement of Science, says: "The evil effects of scale are due to the fact that it is relatively a non-conductor of heat. Its conducting power compared to that of iron is as 1 to $\frac{37}{50}$. This known, it is readily appreciated that more fuel is required to heat water through scale and iron than through iron alone. It has been demonstrated that a scale $\frac{1}{16}$ of an inch thick requires the extra expenditure of fifteen per cent. more

fuel. As the scale thickens the ratio increases. Thus, when it is one-fourth of an inch thick, sixty per cent. more is required; at one-half inch, one hundred and fifty per cent., and so on. To raise steam to a working pressure of ninety pounds the water must be heated to 320° Fahrenheit. This may be done through a one-fourth inch iron shell by heating the external surface to about 325°. If a one-half inch scale intervenes, the boiler must be heated to 700°, almost a low red heat. The higher the temperature at which iron is kept the more rapidly it oxidizes, and at any temperature above 600° it soon becomes granular and brittle from carbonization or conversion into the state of cast iron. Weakness of boilers thus produced predisposes to sudden explosions and makes expensive repairs necessary."

On most of Western roads incrustations will form to a thickness of from one-eighth to three-sixteenths of an inch in the course of one year, and increases at a still greater ratio as long as the engine is kept in service. Thus, after four months' time, there will have accumulated in our engines nearly one-sixteenth of an inch of scale. This statement will be verified by a specimen presented for your inspection, consisting of a piece of two-inch flue taken from an engine on the Hannibal and St. Joseph Railroad after three months' service, to which is adhering a scale nearly one sixteenth of an inch thick. If Dr. Rogers' theory be correct, after one month's service our engines will consume three and one-fourth per cent. more fuel than at first; after two months' seven and one-half per cent., and so on, making an average for the year of over twenty per cent. more fuel than they would have consumed if using pure water. This, according to the performance of the best coal-burning engines, making forty-five miles to one ton, will amount to an extra expenditure in fuel of not less than 138½ tons at $2.50, making $346.25 due to incrustations. This, being added to the expense of repairs due to incrustations, will make $703.75. In addition to this the expense of washing boilers may be counted; as by the use of pure clear water boilers will seldom require washing, and the expense of at least $1 per week or $52 per year would be saved to every engine, swelling the total to $755.75, or $519.55 more than the cost of purifying the water by this process. From this it will be observed that to boil sufficient water to supply a locomotive for one year, running 31,200 miles, will require the extra expenditure of $236.25 for fuel. Now, if boiling alone will purify the water, there would be a saving of $519.50

to each engine, or $51,950 for one hundred engines. Besides all this the use of pure water will absolutely prevent all manner of explosions, ruptures and leaks, arising from the effects of incrustations. It will also save a large proportion of the repairs to the machiney, not counted in the above estimate, by always supplying the cylinders with pure dry steam of the best quality, free from loose sediment or grit, which always follows the course of the steam, frequently cutting the valves, pistons and cylinders, and otherwise damaging the machinery of the engine. The use of water free from mud and organic substances, will absolutely prevent the evil of foaming, which so frequently almost unfits an engine for usual services, until it can reach its destination and be washed out. This and many other prolific evils arising from the use of impure water would, beyond a doubt, be entirely overcome. The introduction into a boiler of any so-called remedies, be they powders, batteries, fluids, or any other nostrums, can hold no comparison whatever to this one perfect and only reliable remedy. Any experiments towards the providing of pure water for locomotive use is a step in the right direction, and when railway companies are aware of the fact that in the Middle and Western States the expense due to impure water and incrustation would amount to the enormous sum of about $75,000 a year for every hundred locomotives, we think they can afford to give the subject a little consideration with a view to making some practical experiments by which reliable and satisfactory results may be reached. The matter of thoroughly purifying the water at a moderate expense is so extremely difficult, that your Committee are not prepared to suggest any particular plan other than that already recommended, believing that nothing in this direction can be definitely known without more or less experimenting.

Mr. Towne, of the Hannibal and St. Joseph Railroad, has been investigating for the past two years with an apparatus consisting of an ordinary dome, 25×25 inches, riveted to the top of the boiler in a convenient locality to the pumps of the engine, so that the water supply can pass freely through the check pipes to the top of the dome, where it is discharged and caused to fall upon and ripple over a series of heated plates, circular in shape, provided with a series of ribs or stops on their upper surfaces to retard the momentum of the water, and arrest the sediment as it passes from one plate to another in its course to the boiler. After passing over these plates the water forces its way through a filter, thence to the boiler through a number

of one-inch pipes (as per tracing) through which also steam from the boiler is admitted to the dome, distributing itself around and within the heater, maintaining a constant equilibrium of heat between the apparatus and the boiler. Half of these plates are slightly convex and half concave, causing the water to flow from center to side and side to center alternately, passing through holes or slots in each plate on its way to the filter, and finally to the boiler through said pipes, which extend upwards about five inches, forming on top of the boiler (within the heater) a basin for water and a receptacle for any sediment that might lodge there, whence it could be blown off by means of pipes arranged for the purpose.

The filter was composed of coarse gravel, and soon found to be of no practical use beyond the lodgement of more or less incrustation. The shelves were found to gather from one-sixteenth to three-sixteenths of an inch of incrustation in from six to twelve weeks' time, showing clearly that the principle was correct, but the apparatus entirely too small to arrest all the lime, as the boiler and flues were also found to be thickly coated, especially so directly under the heater where the water had fallen upon the flues scale had formed from one-fourth to three-eighths of an inch in thickness. After running this engine about sixteen months without any satisfactory results beyond that already stated, it was taken in for temporary repairs, and the heater re-arranged with a view to getting the greatest possible amount of heating or plate surface within its capacity. The filter was accordingly taken out, and the boiler cut out to the size of the internal diameter of the dome, and an additional number of plates put in, about one and a half inches apart, filling the dome full, making sixteen plates in all—a plate surface of about fifty superficial feet. In addition to this a circular strip of sheet iron, four feet long, was placed inside the boiler, directly under the heater, its ends being flanged upward about two inches, filling the circle of the boiler, and its sides extending downwards to within a few inches of the bottom of the boiler. This was to prevent the water from the heater coming in contact with the flues, and also to provide a still greater heated plate surface, over which the water must travel before reaching the boiler, making, all told, about eighty-two superficial feet of heating surface. The engine is now running with this apparatus, and although it arrests so much lime and mud that it is found necessary to take out the plates and clean them off occasionally, yet it does not seem to stop all the incrustations, and consequently it is not just the thing. Judg-

ing from these experiments, as well as others, we do not believe that any apparatus of this kind can be got on to an engine of sufficient capacity to purify the large amount of water required for a locomotive boiler. We think the same device, or a similar one, arranged at watering stations along the line, on a larger scale, might be made to do the work effectually at less expense perhaps for fuel than the first plan. If not by that alone, the introduction of chemical assistants, at a trifling cost, might have the desired effect. The first plan, however, would seem to be the most feasible. The importance of this subject cannot be overrated, since it is known that among the many evils of incrustations none are more potent than the fact of boiler explosions from this cause, and nothing can be surer than pure water as a remedy for this class of explosions. There are cases of explosions of boilers at pressures that, without proof to the contrary, may be taken to be very much below their power to resist pressure, showing very clearly that boilers do explode from causes yet unknown. It is, then, reasonable to suppose, since the fact is not known, that impure water and incrustations may be the source of this unknown element of destruction. Should it be, however, only one cause of such terrible disasters, one point will have been gained; for a single remedy absolutely known is worth more than all the speculative theories extant, as it may lead to the development of a final cure, and in time boiler explosions, other than those caused by low water and over-pressure, will no longer be a mystery.

In conclusion, your Committee feel that they are groping in the dark, and cannot conceal from themselves what must be apparent to others that the question is yet an open one, and whether the theory advanced will effect a complete solution of the difficulty yet remains to be proven by actual trial. To this end we would respectfully invite the attention of all interested, and recommend a series (if possible) of exhaustive experiments, without which they are convinced nothing definite in this direction can ever be known.

Respectfully,

H. A. Towne, *H. & St. J. R. R.*,
J. Johann, *P. R. R., of Mo.*,
J. M. Boone, *P. F. W. & C. R. R.*,
Committee.

In connection with this report the following letter from J. H. Setchel, Little Miami Railroad, was submitted and read:

Mr. Setchel on Boiler Incrustations.

H. A. Towne, Esq., Chairman Committee on Boiler Incrustations:

Dear Sir,—Originally the water on this road was all very hard; but since the introduction of coal as a fuel the necessity of soft water has been so apparent that strenuous efforts have been made to obtain it.

At Cincinnati the water of the Ohio River is used, and but little incrustation is found in boilers using this exclusively; and even after engines have run on other divisions and have become heavily scaled, a year or two's use of this water will in a great measure remove it.

At Columbus the water of the Scioto River is used, and with about like results. Within the two points named, where the water is mostly taken from wells, it is highly impregnated with lime, forming on flues and boilers a hard, flinty scale. On one division, of fifty-seven miles, we have more trouble than on any other part of the road. Here the water is taken from wells and is very hard; and, in running this division, we can take engines upon which we are required to do more or less flue work every few weeks, and by transferring them to the main line we are enabled to run them without difficulty. I can account for this only on the score of the difference in the quality of water used.

We do not take out flues for the purpose of cleaning them, but run them as long as they can be kept tight. Copper flues, in engines burning wood, will run from 150,000 to 200,000 miles. Iron flues, in engines with coal as a fuel, will average from 50,000 to 80,000 miles. We find that the life of the bottom part of boilers seemingly varies with the quality of iron used. We sometimes find a new boiler eaten out in spots in the bottom part after running three years. This I attribute, to some extent, to the rough places often left in iron by using too much sand on the rollers while the iron is in process of manufacturing. In forming sheets into shape this sand that has been pressed in the iron often drops out and leaves a thin, rough place in the sheet, to which the scale adheres and enters on the work of destruction, and subsequently form the eaten places for which the bottom sheets are taken out. I know the destruction of the bottom part of boilers is often attributed to scale and vegetable matter held in solution in this part of the boiler; but, when you learn our method of cleaning boilers, I think you will agree with me that this can hardly

be the case here. I have tried most all the "sure remedies" for preventing and removing scale that has been in vogue for the last five or six years without any positive good result. I have used John Bull's scaling powder in boilers that were thickly coated, and have found that it will remove scale to a noticeable extent. The engines would steam better and large quantities of scale and mud would be taken from the wash-out plugs for awhile; but, in my experience, I find that at certain seasons of the year our boilers will scale more or less without any artificial means being used. Our freight engines are run one hundred and twenty miles four days in the week. This gives two lay over days, and on one of these days the water is let out of the boiler when comparatively cold, and the bottom part of fire box is thoroughly cleaned of all mud and scale. A two-inch hand hole plug is placed at each corner of fire-box that readily admits of the introduction of rods and hose nozzles for this purpose. In the front end, at bottom of flue sheet, is another hand hole plug large enough to admit of a rod with auger or hook-shaped end. Once every two weeks this plug is removed and the cylinder part of boiler is thoroughly washed together with the leg of fire-box as before. This process keeps the boiler free from mud, but does not, of course, prevent the formation of scale. To effect the latter I have tried almost everything. Of the mixtures to put inside for the purpose of removing scale I have found none better than the one before mentioned—"John Bull's." I am now experimenting with Hay's "Galvanic Battery" on three boilers; but it has not yet been in use a sufficient length of time for me to form any opinion as to its merits. I know of nothing that will effectually prevent the formation of lime in boilers. I should think that, where water is used containing sand or vegetable matter in solution, a filter might be useful in arresting such impurities. Some years ago we were a great deal troubled by the filling up of the space between the crown-bar by deposits of mud and scale, but since the practice of giving an inch clearance under the bar has been adopted, and the quality of water been improved, we have little or no trouble from this cause.

Respectfully yours, J. H. SETCHEL,

Master Mechanic Little Miami Railroad.

Chemistry, Physics, Technology, etc.

NOTES ON THE VIENNA UNIVERSAL EXPOSITION.

(From our German Correspondent.)

LEIPSIC, *November*, 1872.

The preliminary arrangements for the World's Fair to be held in Vienna during the summer of the year 1873, have progressed so far as to enable me, especially in what concerns the arrangement of the buildings, to form a correct idea of its character.

In the following description, I have confined myself generally to facts as promulgated from official quarters, adding, however, thereto such few comments as seemed to be warranted from personal observation.

In the great fairs which have heretofore been held, the object has been kept constantly in view to display the accumulated master-pieces of human genius and industry in a building which should, in its grandeur and elegance, be worthy of its contents; so that the palaces which have been erected for such purposes have made an impression upon the minds of the visitors of the expositions no less lasting than the objects of art and industry therein displayed.

Many of these palaces have been removed at the close of the exposition which they served. Others, again, have outlived their temporary purpose, and have remained standing; so, for example, has it happened with the Sydenham Crystal Palace and the Palais de l'Industrie—the first of which served its original purpose in 1851, the latter in 1855.

In arranging for the coming World's Fair, in 1873, it seems to be one of the chief objects of its Director-General, Baron von Schwarz-Senborn, to accomplish the erection of a palace which shall, in its plan, extent and surrounding decorations, be in no particular inferior to those which have preceded it.

The efforts which are being made with this object in view are notably aided by circumstances of a local nature. The city of Vienna possesses in her Prater a natural park which, no less by its extent than by its picturesque beauty, is admirably adapted for the purposes of such an exhibition.

With this excellently adapted location, it is rendered possible to appropriate to the purposes of the Vienna Fair an area which shall surpass all others previously held, not excepting that of 1867, in Paris, on the Champ de Mars.

The accompanying table, containing the areas of former exhibitions, will serve to show this feature by comparison with that appropriated for the coming event:

The space included for the purpose of the Exhibition was, at

London (Hyde Park),	1851, =	81,591	sq. metres.
Paris (Champs Elysees),	1855, =	103,165	"
London (Brompton),	1862, =	186,165	"
Paris (Champ de Mars),	1867, =	441,750	"
Vienna (Prater),	1873, =	2,330,631	"

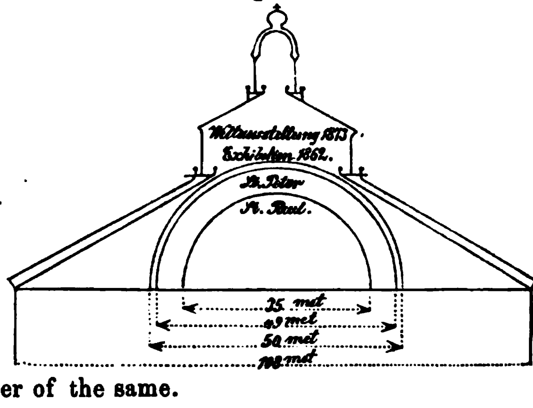
From this tabulation it will appear that the area at disposal for the Vienna Exposition will exceed that of the Paris Exposition of 1867 more than five times.

The three main buildings (Plate I)—the Palace of Industry (1 and 2), the Machinery Hall (3), and the Fine Art Gallery (4)—are, in total dimensions, as well as separately, quite as extensive as the Paris Industrial Palace. The covered space, however, devoted to the Industrial portion of the Exposition can be very largely increased by covering the empty spaces between the numerous cross galleries of the main building.

Without making use of these possible extensions, the covered space included within the three buildings is 108,947 square meters.

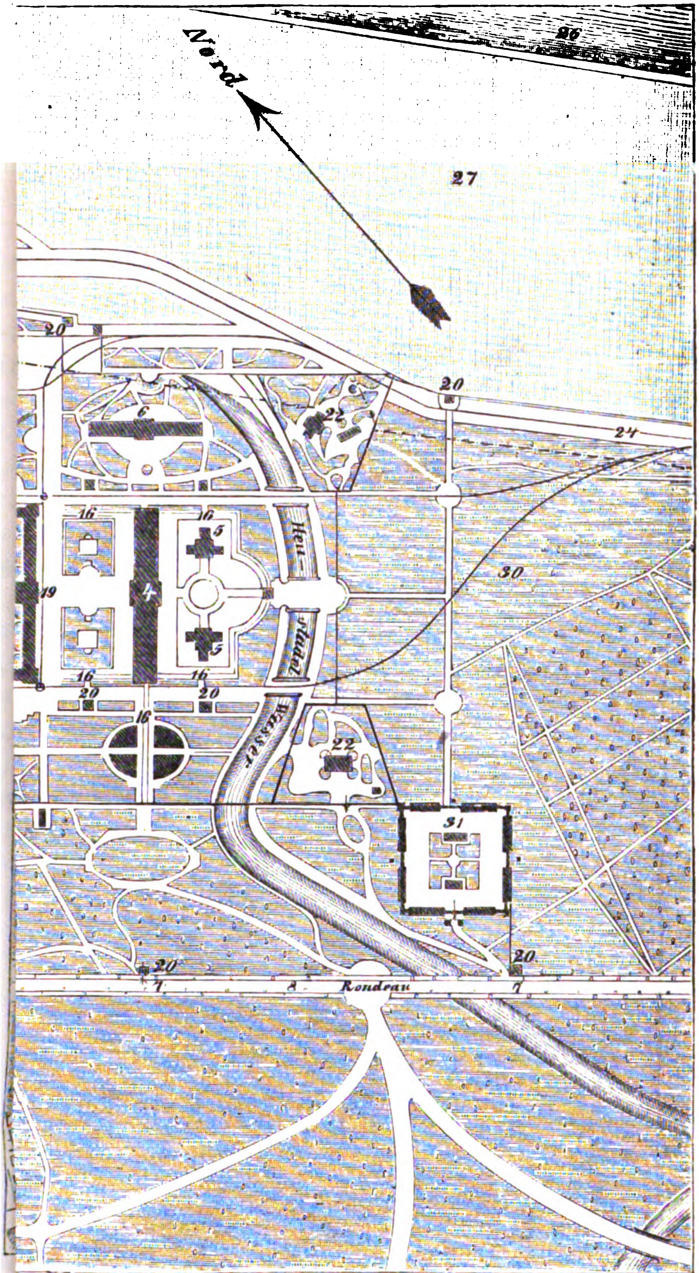
Whether the place devoted to the exhibition in general, is greater or less than those which have preceded it, is to a certain extent of little account, since it is impossible to place the objects on exhibition beneath the free sky; but upon the extent of the covered space provided the success of such an exposition is dependent, for it has regularly been a source of regret that in this particular all previous attempts have been to some extent inadequate to the demand made upon them for accommodation.

Fig. 1.



The work of erecting the buildings has been entrusted to Mr. Carl Hassendeur, who is likewise the designer of the same.

The great Rotunda (Fig. 1) forms the central point of the great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building. It was constructed after plans of Mr. Scott Russell, the well-known English engineer—the designer of the Great Eastern and of the Sydenham Glass Palace.

The span of this immense dome measures 108 meters, and it is therefore more than double the size of the greatest in the world, viz., that of St. Peter's, at Rome (Fig. 1).

In order to afford a comparison, the accompanying illustration affords a view of the relative dimensions of the Rotunda at Vienna, that of the Industrial Exhibition building of 1862, that of St. Peter's Church, at Rome, and of the St. Paul's Cathedral, at London; from which comparison a just conception of its magnitude may be obtained.

Concerning the Rotunda itself, your correspondent would as yet venture no opinion, for during his presence on the Exhibition grounds the rafters for the same were not yet laid. To judge, however, from the plan proposed, it may be safely inferred that the funnel shape which it is designed to give it will not make by any means the striking impression which would be formed of one having the classical rounded outline.

Accurately stated, the exterior diameter of the Rotunda is 107·83 meters, and its height 84·1 meters. A rounded roof, supported upon 31 iron columns, 24·35 meters high, rises, with an angle of 31°, to a height of 48·2 metres, and is terminated by a central ring of 30·9 metres diameter. The exterior of the roof is covered smoothly with sheet metal, and, viewed from below, has the appearance of a smooth truncated cone.

Upon this conical roof is placed a so-called Observatory, composed, like the rest of the structure, entirely of iron, the outer diameter of which is 32·4 metres, and the height 10 metres. The roof of this Observatory is made parallel in angle with that of the main roof below, and rises 7·4 metres.

Upon this, finally, there is placed another building, 8 metres in diameter and 18·5 meters high, which terminates in a crown, whose highest point is 84·1 meters above the flooring below.

At a height of 23 meters in the interior of the Rotunda there is placed a gallery, directly against the pillars, having a breadth of 142 meters. This may be reached by two stairways, on opposite sides of the Rotunda, or by two elevators, introduced for the purpose.

The stairway leads upwards to the main roof, from which, by a continuation of the stairway, the gallery in the crown above may be

reached. This second gallery is doubled in such a way that one may inspect from it not only the interior of the Rotunda, but also from another portion of it have a clear view of the entire Exhibition grounds.

The interior of the Rotunda is lighted by windows, brought between the pillars of the Observatory.

The entire space covered by the Rotunda measures 338·8 metres in circumference, and the surface covered by the roof measures 9405 square meters, the interior circumference is 319·6 meters, and the space available for the purposes of the Exhibition and accommodation of the visitors is 8129 square meters.

To give an idea of the forces operating upon the various portions of this structure, a few data are attached.

The vertical pressure upon one of the iron columns of the Rotunda = 109 tons. Pressure on the lower portions of the radial rafters = 211 tons; horizontal strain on same = 181 tons. Tangential strain on the lower roof ring = 863 tons. Pressure on the upper ring, upon which the Observatory rests, = 217 tons.

The total weight of the structure of the Rotunda may be stated in round numbers at 80,000 hundredweight (Zoll centner), or about 4000 tons.

The pillars rest upon béton foundations, which were prepared for this purpose as early as October 30th, 1871.

The delivery of the iron work began upon the 1st of January, 1872; and, according to the terms of contract, should have been completed by Sept. 15th, 1872. At the time of this writing, however, there still remains a portion to be delivered, though the greater part of the work is finished.

Leading from the Rotunda is the main gallery (see Plate I), having a width of 25 metres and a total length of 905 meters. This main gallery is crossed, at regular intervals, with 16 lesser galleries, placed at right angles with the main gallery. These cross galleries have a width of 15 metres and a total length of 205 meters. By this construction there is formed in the two sides of the main gallery 24 courts, or empty spaces, enclosed on three sides, all having the same length as the cross galleries, and a breadth of 35 meters.

These courts permit of an excellent lighting of the entire series of galleries, by high side-lights, and obviate the necessity of constructing glass roofs, to which so many inconveniences attach, particularly in regard to their protection against the rain. They materially aid

in the ventilation of the buildings, and they permit of a very considerable increase in the extent of the buildings, should the necessity for such an increase in dimensions be found necessary.

The whole plan of the Exposition buildings is extremely convenient and simple, and the advantages which it affords in its freedom from complicated passages, &c., and the ready accessibility of all parts of the Palace from without, are unequalled by any previous arrangement for similar purposes.

The impression which is excited by the Exhibition Palace is by no means an imposing one, whether viewed from without or within. It is possible that an opinion expressed at this stage of the work is an unfair one, since the effect of an elaborate and decorated finish may vastly improve the appearance of what now seem like the empty halls of a vast magazine. Perhaps, too, the exterior of the great building may gain vastly when properly finished. The want of light in the interior will, however, be seriously felt, and must be regarded as one of the weak points of the Exhibition arrangements. Your correspondent several times visited its interior, and even with bright sunlight the interior of the vast rooms presented a dusky, dismal appearance (Plate II).

From an architectural standpoint, Hafenauer has divided the Palace into three parts—one large quadrangular main building, the centre of which is formed by the Rotunda, and two end buildings, enclosing the rectangular courts before alluded to.

Besides the 32 entrances to the buildings on the sides of the cross-galleries, there are four grand portals, of which one is designed for the reception of the visitors coming to the grounds by way of the Prater-allee (8), and one for those arriving through the Feuerwerks-allee (17).

Behind the Palace of Industrie rises a long building, almost equal in length, the Machinery Hall (3). In this it is designed to expose to the visitors, in full operation, the machines which are exposed for exhibition.

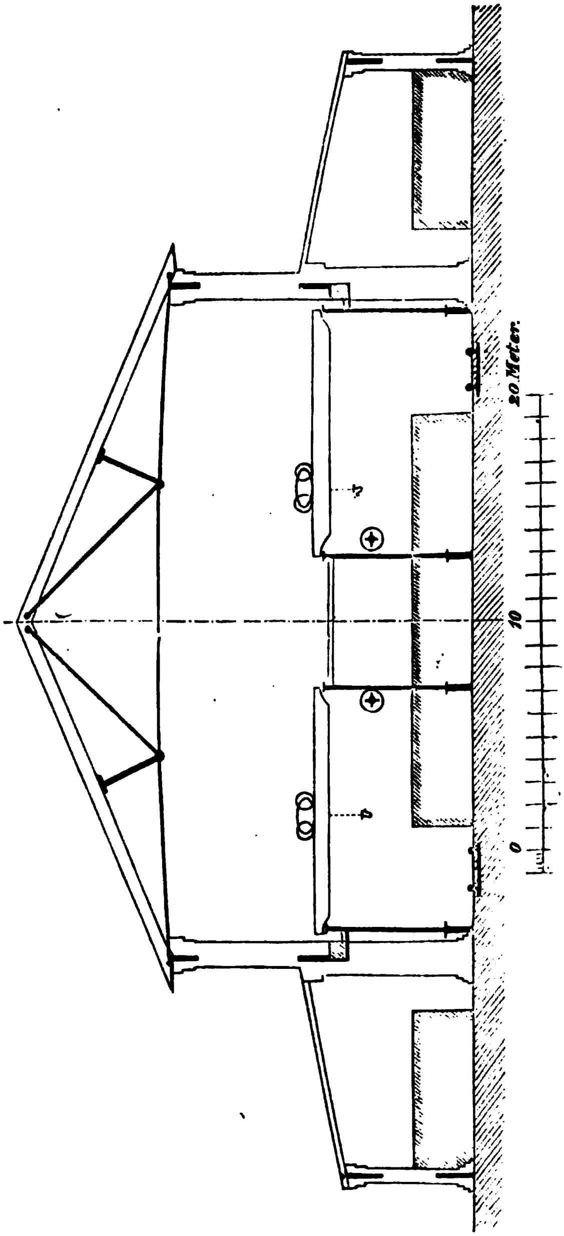
This building has a length of 800 meters, and a breadth of 49·6 meters.

A cross section of the hall is shown in Fig. 2. Two railway tracks are laid at the sides of the central portion of the hall, and pass through its whole length.

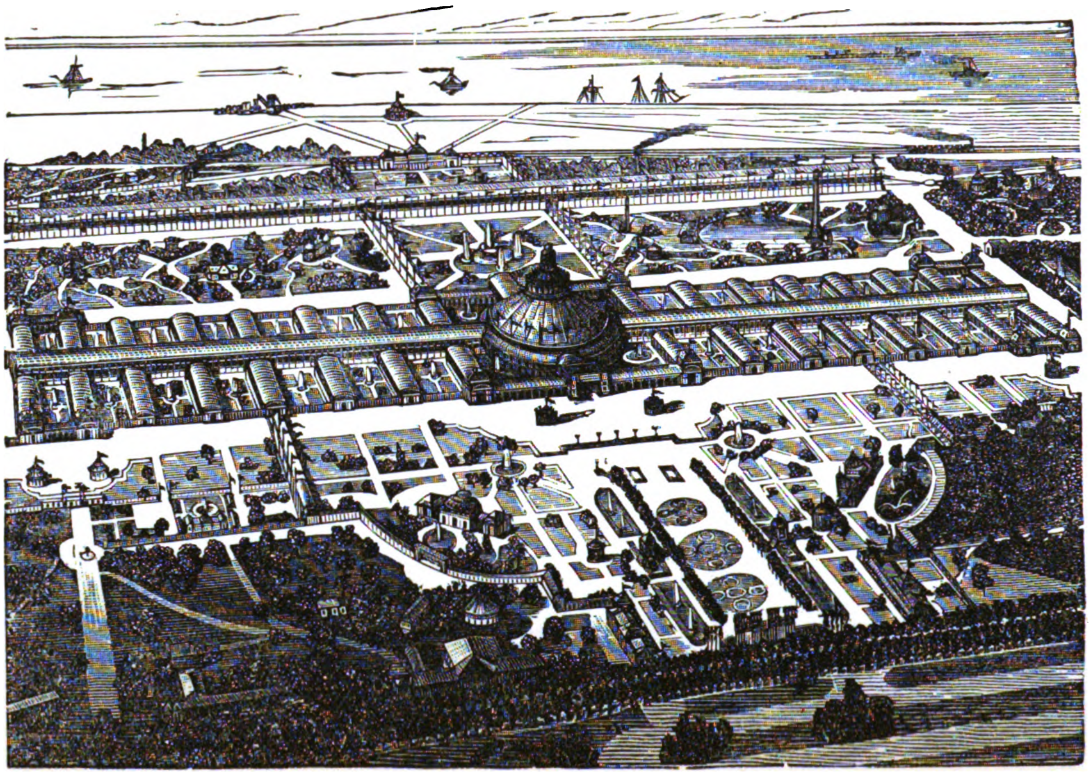
Four rows of pillars carry the rails for a number of transporting cranes, and serve at the same time as the points of attachment for

the two main driving shafts, which run through the whole length of the hall. As may be drawn from an inspection of the illustrations, the machinery hall does not present in its architectural design any

Fig. 2.



Vienna Universal Exposition, Plate II.



particular points of interest; it likewise appears to lack in that essential so badly needed in the great building, namely, a sufficiency of light.

The main nave of the Machinery Hall is large enough to permit of the display of an operation of machinery of moderate height; the side naves, on the contrary, afford but small and confined spaces for the same, and it is difficult to understand why such a disadvantageous arrangement of space for a world's fair could have been projected.

The mechanical and engineering portion of the Exposition is under the superintendence of the Court Councillor, von Angerth, as Chief Engineer. To aid in the proper carrying out of the objects of this portion of the work, there have been associated with him Professor von Grimburg, in the department of machinery, and Inspector Heinrich Schmidt, in the department of engineering.

Opposite the south end of the Palace of Industry is located the building devoted to the Fine Art department of the Exposition—a four-naved building, along the middle portion of which is a double row of large saloons, lighted from above, for the display of larger pictures. On both sides of these central saloons are arranged smaller halls, with side-lights, designed for the display of pictures of less size.

The space between the Fine Art Gallery and the Palace of Industry will be taken up by the display of statues and other objects of art; while the grounds will be converted into a park, to add to the pleasing effect of this branch of the Exposition.

Adjoining the Fine Art Gallery, and connected with it by a covered corridor, are attached two pavillions, for the exhibition of the collections of amateurs—an idea of the General Director, Baron von Schwartz-Senborn; which, if properly realized, will add to the treasures of this department the riches of numerous private collections, and greatly enhance its value to lovers of art, and in an educational point of view.

Upon one side of the Fine Art Gallery is placed a large conservatory, and upon the other an aquarium.

Between the main avenue of the Prater and the Palace of Industry the grounds have been converted into an elaborately decorated park (10), at the sides of which the visitor will observe a number of pavillions, of which one is appropriated for the use of the Imperial Commission having the Exhibition in charge (12), another for the postal and telegraphic service (13), a third for the judges (15), and a

fourth, furnished in the most magnificent style, is set apart for the use of the Imperial Family (14).

Numerous covered ways, branching right and left from the main entrance, are provided to meet the possibility of wet or unfavorable weather, so that the public may enter and leave the Exposition grounds with every convenience. The space between the Palace of Industry and the Machinery Hall, as well as to the Fine Art Gallery, is similarly protected by covered ways.

The portion of the park lying between the Palace of Industry and the Machinery Hall (21), is designed for the exhibition of various works of architecture.

Below the Art Gallery an arm of the Danube, spanned by three bridges, separates the Exhibition grounds proper from an extensive park (30), which, in connection with the broad Danube embankment beyond (27), is designed to serve for the exhibition of agricultural implements, horses and cattle.

The embankment named above will also be used for exhibiting the operation of hydraulic machinery and apparatus.

The methods of intercommunication are both numerous and complete.

Two railways—the Northern Railroad (23), and the State Railroad (24)—will carry passengers, at all hours of the day, to the depot (25), behind the Machinery Hall, and in addition steamers will ply upon the Danube (26), to the Exhibition grounds.

It had also been designed to facilitate the transportation of the daily crowds of visitors to and fro from several portions of the extensive grounds by introducing tramways, to be operated with a wire rope and clip pulley, but, unfortunately, this plan appears to have been abandoned.

The several horse railways will likewise extend their tracks to within a short distance from the Exhibition buildings.

The accommodations arranged for carriages and other conveyances (29), are very extensive, and include space enough for about 2000.

It may, therefore, in view of what has been presented, be confidently expected that the contemplated Exposition in Vienna will in no wise prove to be inferior to those which have preceded it.

For the various mechanical industries, the following special information concerning the display of machinery may prove of interest:

Special Regulations concerning the Exhibition of Machinery.

1st. The Machinery Hall is intended for the exhibition of objects included under Group 13 (Machinery and Devices for Transportation).

From this department is excluded such machines as will by their operation annoy the visitors, or such as would injure the other objects on exhibition, or any which in the judgment of the direction interfere with the greatest good of the greatest number. The exhibition of such excluded machines can only take place without the Hall, in the open air, or within a covered space erected at the expense of the exhibitor.

2. Exhibitors of machines and apparatus are required to state—

(*a*). The space required by them, in meters, both in length and breadth.

(*b*). The amount of wall space required, as before, in meters, indicating both breadth and height.

(*c*). The power required to run their devices, stated in actual horse-power, or in kilogramme-meters.

(*d*). The required quantity of steam, stated in kilogrammes or cubic meters per hour, and the steam pressure in atmospheres.

(*e*). The required water supply, stated in cubic meters per hour.

(*f*). The required gas supply, stated in cubic meters per hour.

3. The Foreign Commissioners to the Exhibition are requested to report to the General Director the extent and nature of the machinery to be set in operation, by the 1st of August, 1872, at the latest.

4. Machinery and other devices for exhibition will be admitted into the Machinery Hall from the 1st of February, 1873, until the 15th of April, 1873, and must be completely arranged for exhibition or operation by the 25th of April, at the latest.

Machinery or apparatus which are sent in parts, and are composed of large and heavy pieces, are required to be erected by the 15th of April, at the latest.

Walled foundations must be erected at the cost of the exhibitor, and are required to be finished and ready for the reception of their appointed machines by the 15th of March.

5. In the interior of the Machinery Hall, and round about it, railways have been provided, so that the objects to be exhibited can be transported to the immediate neighborhood of the place set apart for them.

6. Upon these tracks a number of cranes will travel, which are designed to aid in the unloading and erection of the machinery.

In addition to these, travelling cranes on elevated roadways will be provided for the same purpose.

7. The flooring of the machinery hall will be of unusual strength and solidity—so that even very heavy machines may in most cases be erected directly upon it without special foundations.

8. The power needed to set and keep in operation the various machines on exhibition will be furnished free of cost by the administration of the exposition. The arrangements for obtaining supplies of steam, water or gas, from time to time, must be made with the general director.

9. The power will be distributed by two horizontal driving shafts. These shafts are 0.09 meters in diameter, and make 120 turns per minute. They are placed 4.5 meters above the flooring, and are supported appropriately from the pillars of the building. (The position of these shafts may be seen by inspecting fig. 2).

10. The exhibitors are required to provide, at their own cost, the driving-pulleys for the main shaft, as well as all other parts, such as pulleys and belts, which may be required to operate their machines.

The driving-pulleys must be made in two parts, to permit of being attached to the shaft. The attachment of these pulleys must be so effected as not to injure the shafts.

11. All machines which are intended to be set in operation must be placed in the central division of the machinery hall. In addition to this, the machinery of the several countries represented in the hall must be placed side by side in such a manner as to form one uninterrupted series. The driving shafts will only be extended so far as may be required by the grouping. The maximum amount of shaft-length to be assigned to the various nationalities will be made known to the respective commissioners on the 31st of August, 1872.

12. The preservation, cleansing and lubrication of the main lines of shafting will be undertaken and attended to by the authorities; but exhibitors are expected to look after the preservation, cleaning and lubrication of the machinery, pulleys, belting or other gear employed by them.

13. Should machines be presented for exhibition, designed to be shown in operation, which cannot be driven from the main line of shafting above, subterranean or other mode of transmission will be supplied for these cases, if deemed sufficiently important to warrant such unusual attention.

14. Where machines presented for exhibition require to be operated outside the machinery hall, special arrangements will be made in each case by agreement with the exhibitor.

15. The daily working time during which the machinery may continue in operation will be announced by the authorities before the opening of the exposition. The exhibitor is required to provide the attendants he may need, to run and keep in order the machines he may present for exhibition; for no person except those specially provided by the exhibitor will be authorized to touch or set in motion any machine.

16. All machinery in motion must be isolated by a railing, or some similar arrangement, in order that visitors may be suitably protected from possible injury.

17. Machinery and apparatus designed to serve specially the wants of the exposition, may be delivered to the authorities for the purpose, and will be classified under group 13.

Amongst these machines there may be classed the following:—

(*a*). Steam boilers for generating power for the machinery.

(*b*). Steam engines for driving the shafting in the machinery hall.

(*c*). Gas machines or water power machines for operating special machines, or pumps of machines.

(*d*). Pumps, large and small, for affording water supply.

(*e*). Hoisting cranes for aiding in the manipulations of the machinery hall.

(*f*). Travelling cranes, with a gauge of 10.5 meters from centre to centre of the rails, for transporting and erecting heavy objects and machines in the machinery hall.

(*g*). Hydraulic machinery.

(*h*). Locomotives to be employed for the purposes of the exhibition without the hall.

18. The exhibitors of machinery or apparatus to be devoted to the special uses of the exhibition will be allowed special privileges; but in every case these privileges must be arranged by agreement with the director general.

19. The machines and apparatus handed over to the authorities to serve the purposes of the exposition will be specially tested by them.

Steam boilers will be tested as to their consumption of coal and their steam generating capacity. Steam and gas machines will be tested as to their power by indicator or dynamometre tests. The re-

sults obtained by these tests will be made public upon report of the exhibition.

For the convenience and to meet the possible want of the exhibitors, a workshop, furnished with the several standard machines for turning, cutting and shaping metal, will be attached to the machinery hall. In this workshop such small work and repairs as may be needed by exhibitors can be done, in accordance with regulations imposed by the authorities.

The administration of the workshop will be under the control of the authorities, and price of the work there done will be regulated according to a tariff arranged by the authorities.

Besides these regulations for the special administration of the machinery department of the exposition, the general regulations will be likewise enforced.

The General Director,
BARON VON SCHWARTZ-SENBORN.

Very truly yours,
WILHELM H. UHLAND.

GEOLOGICAL SURVEY OF PENNSYLVANIA.

To His Excellency, Gen. J. F. Hartranft, Governor of the State of Penna.

PHILADELPHIA, February 1, 1873.

SIR:—You have done me the honor to say that, if I have any information likely to be useful in proposing a geological survey of Pennsylvania, you will be pleased to receive and consider it.

I reply, that all well educated persons now recognize the importance of increasing human knowledge, believing not only that there is no limit to be put to this increase, but that every kind and quality of knowledge is, or will be, in some way or other, useful. Uneducated people find it hard to assign value to what looks to them abstract and unpractical, but business men who have had most experience and the best success in life, comprehend pretty well that the collection of natural facts and the discovery of natural laws are the foundations of civilization and the causes of American prosperity.

To collect facts and to arrange them for discovering laws of nature is an expensive and painful occupation. It is the business of men trained for that purpose; apart from the common transactions of mercantile and manufacturing society; unremunerative, and demanding the patient industry of the whole man, throughout his whole life.

And many such trained minds must work together to accomplish results useful to the Commonwealth. This is true for every kind of scientific work. It is especially true of geology.

It is not generally known how entirely the buying and selling of mineral lands depends upon the private surveys and reports of professional geologists of established reputation for knowledge and truthfulness. Mining enterprises of respectable size are never undertaken now without first obtaining from some competent geologist a careful statement of his observations and advice; precisely as no railway is now built except upon the well considered report of an experienced Civil Engineer.

But these advantages are monopolized by the few who are able to pay for such surveys. A State geological survey is therefore essentially democratic in its nature, having for its object to prevent monopoly, and to publish such knowledge to all the citizens of the Commonwealth without regard to fortune. Knowledge which is bought at such high prices by wealthy landholders and incorporated companies *must* be desirable for all the farmers of the State; for the householders and trades-people of all its towns and villages; for every manufacturer and artisan. however modest may be the part he plays in the business community. A survey costing annually $50,000, or $100,000 per annum, furnishes to the population of Pennsylvania, at the rate of five or ten cents per voter, information for which energetic speculators, large land-owners, and wealthy manufacturers are constantly paying from $500 to $2,000 apiece. And having paid such high prices for it they naturally keep it to themselves. Whereas the interests of the Commonwealth demand that it should be published to all citizens.

But a still stronger argument for a State Geological Survey comes from considering that geological knowledge requires the widest range of facts to make it reliable. There were many observers of the weather and good local weather prophets before the establishment of the Weather Service Bureau at Washington, two years ago. But no real knowledge of the weather was ever got by these private observers, sufficient to predict the great waves of cold and heat and wind. It required a Government survey to accomplish this.

Just so, the local geology of this or the other man's property would be pretty much all costly guess work, but for the State Geological Surveys of 1836—1841, and 1852—3. That great work sketched out the general geology, studied details of the most important dis-

tricts, put the parts and fragments together, established rules and probabilities, recorded average measurements, and trained the professional geologists who, ever since then, have been surveying properties for mining, smelting and railway interests. The first mineral State of the Union would be in a pretty situation to-day but for that State Geological Survey; much such a situation as a great warehouse without ledgers and clerks.

Twenty years have passed since the Geological Survey of the State ordered by the Legislature was ended. It is surely high time to recommence.

The first survey was in most parts of the State very imperfect. Parts were carefully surveyed and well described; but whole sections, now among the most important, were merely sketched out. These require accurate surveying and description. In a word, the first survey was, in the very nature of the case, and at that early day, merely preliminary to a better and future one. This better survey ought now to be undertaken.

I will insist no longer on the need of a Survey, but proceed to consider its character.

The points of most moment are as follows:—

I. Good maps are the basis of all useful research in every department of science and the arts, and especially in the political science of statistics, and in the practical sciences of geology and metallurgy. The geologist's work must be inaccurate and costly to his employers and to the community wherever no good map has been made of the ground. The first step of our geological survey ought to be the construction of a perfect map of the State; or at least of those parts of it which are to be first studied geologically.

We have sufficiently good maps of a number of counties. But the counties of the northern, middle, western and south-western counties have no maps which are of the proper value to a survey. These should be mapped with road odometer surveys, as fast as practicable, taking them up in the order of their geological importance. Meanwhile the United States Coast Survey will obtain for us the absolute determination of one fixed point in the centre of each county; and triangulate for us, or at all events, greatly assist us in triangulating parts of the State on a sufficiently large, rapid and cheap scale to enable us to rectify and connect the county maps into a whole.

I have the assurance of Prof. Pierce, Chief of the Coast Survey, of the great interest he takes in our State Survey; and he is now con-

necting the shore lines of the Coast Survey across the continent; which connection will take place partly through Pennsylvania.

I deem it inexpedient to call for a new State Map at first. That will grow out of our County Surveys, and must wait for the astronomical and telegraph-time work; whereas the county odometer surveys can go on at once and rapidly. Two men (*i. e.*, a surveyor and his rod man) can survey a county in a year at an expense of about $3,000, or $2,500. We have very good practical county surveyors about the State; and if we had the money we might have a County Map of every county in the State by this day two years hence. But a surveyor should know something about geology; and the training which our county surveyors and their boys will get by this connection of road running with geological surveying ought to be one of the strong arguments in its favor. A geological survey when continued from year to year becomes a great and powerful school for several kinds of people, increasing their public usefulness in their professions and employments.

I should advise the mapping of five or ten counties per annum. When Robert Smith, the map publisher, had expended $80,000 in mapping most of the counties of New York, he applied to the legislature of that State for aid to map the remaining wild counties where he could get no subscribers, in order to collate and publish a State Map. This was done by an act requiring every school district to purchase a copy or copies of the State Map and, I believe, of the county maps also. The cost of the work was more than covered, and at the same time the full publication and useful distribution of the State Map was secured.

The single counties ought to be published on a small scale as fast as made; and geologically colored as fast as studied. One uniform scale and size of page should be adopted, so that a handy atlas would be the final result. Cheapness and accuracy rather than artistic finish ought to be aimed at; the latter can be attained after the general wants of the public are satisfied. With our present art of printing and photographing, every man and child ought to have a colored geological and geographical (topographical) map of his own county (with a small scale map of the whole State) put into his hands for a few dimes; and that of the highest scientific correctness and completeness.

The model for a publication of this sort is a handy and handsome octavo Atlas of the Geology of England, in 33 colored plates, inclu-

ding a plate of England, and one of Scotland, the rest being plates of one county, or two adjoining counties, with every town and hamlet, small stream, road, railroad and park exhibited with perfect distinctness; the geological formations being colored over all. It seems impossible to improve on this book. It is sold very cheaply and is in the hands of a great many tourists and commercial travelers. It is prefaced with 16 pages only of geological explanations, including "Agricultural Geology and Water Supply." The maps of the Geological Survey of England formed the basis of this beautiful little atlas of Reynolds. And without the government surveys this useful popular manual would have remained an impossibility.

I consider the large and unwieldy county and local maps published by some of the State Geological Surveys of the United States mistakes. Everything needful can be shown on a smaller scale, with equal accuracy, and far greater convenience to the reader, tourist, and student in the field; with large saving of expense to the State.

The main point to be insisted on is the desirableness of laying the results before the public in a useful and accurate but cheap form; and as fast as the work advances, without waiting for the difficult and tedious compilation of an entire State Map.

Absolute perfection in science is unattainable. However accurately work may be done, still greater accuracy will be possible; however complete a long and patient study of a region or locality may make our knowledge, longer and more accurate study will always still further improve our knowledge. The very name of *Final* Geological Report should be abandoned. It is an absurdity. It has seduced ambitious men into a policy of postponing the publication of their researches long after a mass of most useful information for the public has been collected; for fear that errors have been committed, important details been overlooked, and their personal reputation may thereby be endangered. The right policy of a State Geologist, or of a State Geological Corps of Geologists, is to hand over to the public all reliable information as fast as obtained; as fast as consistent with conscientious carefulness.

I would urge, therefore, the prosecution of our State Survey by districts; and the publication of its maps by counties; in a cheap but handy uniform shape; to make an atlas which should grow in size from year to year. Of course the most important and the least understood districts should be surveyed and published first.

II. While a Geological and Metallurgical Survey of the whole State

has been demanded by the general voice of the business community, and for the land ownership of all parts of the Commonwealth, it is especially needed in the oil regions of the northwest counties, in the new bituminous coal basins of the western part of the State, and at the iron smelting and rail purchasing centres.

There are whole districts of the State's surface which remain as yet to a large extent unstudied by competent geologists pursuing the best method of research. There are problems of structure and deposit involving millions of dollars of value still unsolved, which nothing but well developed instrumental field-work can solve.

The old survey did a great work. It clearly portrayed the main features of the State. It told us exactly where to look for what we want to find. It has given us a very magnificent sketch, which we may now fill up. The new survey will not cost half as much, in time and money, as it would have cost had no previous survey been made. But when the survey was made in 1836—1841, there were no county-maps; no State map but Melish's, which was full of errors in the best settled counties, and good for nothing in the back counties; and almost no good exposures of our mineral veins except in the anthracite coal basins and around Pittsburg. Now, the soil is everywhere full of trial shafts and trial explorations; the forests have been extensively cleared; roads penetrate what were then inaccessible districts; railroad lines and branch lines have covered whole counties with instrumental field-work; twenty thousand oil and salt wells have been bored; hundreds of mining properties have been put into working order; the population of the State has grown intelligent, observant, and enterprising; and the scientific and practical skill of geologists, metallurgists and surveyers has reached a high pitch. We are now able and ready to grapple with the many difficult questions of number, order and quality of our coal beds; where they run, how they lie, how they can best be mined, and how best connected with market. We are prepared to get full and accurate information about the oil, to show on maps the extent of the oil regions, and the depths to which borings must be sunk. We are, above all, ready and able now to take up the iron problem of the State, and find out the law of the deposits of the brown hematite ores.

III. I have stated the wants of the present generation. The next has also claims upon us. A most important function of a geological survey is to *preserve* knowledge *for future use*. Science is cumulative. It makes slow and painful advances. It is obliged to collect

an abundance of facts before it comes to true conclusions. Pennsylvania has lost enormously during the last twenty years by having no bureau of statistics, no corps of observation and publication, to observe and preserve, collate and relate the facts of its geology and mineralogy as they have made successively their appearance. No Commonwealth can afford to be without such an apparatus for preserving from loss and forgetfulness the discoveries and investigations of private persons, even for one single year of its existence. Thousands of most valuable facts have been lost to us during an interval which cannot be recovered. How many openings on coal veins are now covered up, no one being able to give any reliable information about them! Twenty thousand oil borings have been made, and not one hundred of them are on record, if discoverable. Hundreds of gangways have been driven and abandoned, and cannot now be studied; many of which would disclose the nature of faults and disturbances which affect neighboring properties, and overlying and underlying beds not yet worked, where certain knowledge is preserved to govern the future mining engineer in his plans for getting at the mineral. He must work as completely in the dark as if his knowledge had never been got, and often paid for at a ruinous expense. The sooner a geological survey is established the better for the *future* interests of the State as well as for its present necessities.

IV. Geology and Mineralogy must carry on work in several different departments at the same time. A mapping office, a chemical laboratory, and a museum of minerals and fossils are necessary to good field-work. The field-work must be done by three kinds of experts working in harmony and mutually assisting each other: surveyors, geologists and palæontologists, or fossil-shell and plant students.

A complete working corps, therefore, should consist of:—

1. A chief or director who is familiar with both topography and geology.

2. A chemist, who must be also a good practical mineralogist and metallurgist.

3. A palæontologist who knows vegetable as well as animal fossils.

4. Assistants in the field to head surveying parties.

5. Assistants in the laboratory and museum.

But a survey of a great State like Pennsylvania cannot be carried on well without a still greater division of labor. For the sciences are now so extensive and difficult that their greatest experts are obliged to limit themselves to one department of one science. I should propose

therefore, if my advice were asked, some such organization as the following:—

1. A Director of the Survey, who shall take charge of the maps and the field-workers, the illustrations and publications of the Survey.

2. A Chemist with his laboratory.

3. A Palæontologist in charge of the museum.

4. A Fossil Botanist to study the coal beds in all parts of the State, in the field.

5. An Assistant Geologist in charge of the Oil Regions.

6. An Assistant Geologist in charge of the topography and structure of the Bituminous Coal Region.

7. An Assistant Geologist in charge of the Iron Ore Regions of Middle Pennsylvania.

8. An Assistant Geologist in charge of the revision of the Anthracite Coal Regions.

9. An Assistant Geologist in charge of the Primary (gold and chrome bearing) rocks of the Southeastern district of the State, and one acquainted with the extension of this important belt of rocks through the Southern Atlantic States.

10. Men employed under the above, to handle instruments when necessary, make collections, draft maps, copy original documents, &c., &c.

It is no economy to employ inferior talent. Mistakes committed by inexperienced and incompetent persons produce not only present waste, but permanent mischief. Men of the best standing in the science would be eager and proud to take part in so great a work.

Young men trained in American and European Mining schools, are waiting to be employed as assistants. We are assured of a large amount of valuable *voluntary* assistance from the members of the Academy of Natural Sciences and from persons in various parts of the State. The Collegiate institutions at Easton, Bethlehem, Lancaster, Pittsburg and other towns would be zealous to co-operate.

V. But men with families to care for must receive an adequate support. Commonly, the lives of such individuals have been spent in the unremunerative acquisition of knowledge, skill, experience and materials, which is only now bearing its natural fruit, enabling them to provide against the inabilities of age. The State should pay well for the best talent, where so much mischief might be done by incompetent persons. A State Geological Survey should not be made a mere stepping-stone to something better, or an advertisement for lucrative private professional work. There ought to be nothing better.

All traveling and carrying expenses ought to be borne by the Survey, and not to come out of the salary of the geologists and assistants. Such expenses can be reduced to a minimum by a candid application to railway companies, who will grant free tickets to the working corps of the Survey; and free transport for their collections. Great hospitality has always been shown to geologists on a public survey by all classes of people. There will still remain expenses which cannot be avoided; but a considerable portion of these fall on the first year of a survey; for instance, the purchase of field instruments and wagons, which are absolutely necessary for a proper and rapid exploration of any district of the State, whether cultivated or wild.

If you desire to know what idea of the cost of a State Survey my experience of such work for nearly thirty-five years enables me to form, I reply, that the cost will be commensurate with, first, the thoroughness and, secondly, the rapidity of the work to be done. The following may perhaps stand as a fair approximation to the truth :—

ESTIMATE OF ANNUAL COST OF STATE SURVEY.

Director,	$5,000	
Chemist,	3,000	
Two Palæontologists,	3,000	
Assistant in Oil Region,	2,000	
" " Bituminous Coal Region,	2,000	
" " Iron Ore Region,	2,000	
" at Pottsville,	2,000	
" " Wilkesbarre,	2,000	
" in Southeastern Pennsylvania,	3,000	
		$24,000
Laboratory (for first year only),	2,000	
Chemist's Assistant,	1,000	
Field party for Oil Region,	3,000	
" " Bituminous Coal Region,	3,000	
Rent of house for Museum,	1,000	
Assistant in Museum,	1,000	
Incidental expenses,	500	
Traveling and Transport expenses,	1,000	
Instruments and Vehicles (first year),	1,500	
		$14,000

PUBLISHING DEPARTMENT:

Draughtsman, ...	3,000	
Lithographing and Wood-cutting, Printing, Binding and Distributing the Work of the Year, with Maps and Illustrations (say 1000 pages 8vo., 10 maps and 100 wood cuts), 5000 copies, .	6,000	
		9,000
Total, ...		$47,000

By including the item of publishing in the estimate we should avoid delays at the close of the year, and make each year's work complete and finished up to date; giving the legislature opportunity to pass judgment on the work, while the public are not kept out of the use of the results as fast as they are obtained.

I do not include the triangular and astronomical determination work in the estimate, because I believe I have Prof. Pierce's assurance that the Coast Survey will relieve the State from this burden to a considerable extent.

I can think of nothing more at present to suggest, and beg you to excuse the great length to which this subject has protracted my letter.

Your obedient servant,

J. P. LESLEY.

P. S.—If the mineral wealth of Pennsylvania is to be properly exhibited at the Centennial Anniversary, a better method of accomplishing this result could not be devised, nor one so cheap, as by the organization of a State Geological Survey.

Consuming Coal Smoke.—Mr. T. B. McCarty has recently been awarded letters patent for a method of producing an increased draft, and of securing a smokeless fire by the use of steam. To carry out his system, the inventor proceeds as follows:—A small pipe conveys dry steam from top of boiler to the upper part of the furnace, where it enters in two small jets, striking downward on the burning fuel. A description of the working of the plan here given states that no sooner is the steam injected into the furnace, than a sluggish, smokey fire springs up into a clear bright yellowish and intensely hot flame, filling the whole furnace with a loud roar.

ON THE COMPOSITION OF ANCIENT CEMENTS AND ROSENDALE CEMENTS.*

By Arthur Beckwith, C. E.

The cements commonly used in New York and elsewhere for ordinary constructions, as well as for large engineering works, have frequently elicited the interest of inquirers into their nature and properties.

Among the best descriptions of the qualities of these cements we may cite General Gillmore's work on the subject, in which we find a list of valuable experiments which set forth the properties of various cements, and also a table showing the chemical composition of a number of cement-stones from which our cements are made.

These experiments and tables do not, however, contain the chemical analysis of the cements themselves, upon which so much depends.

The chemical analysis of several of the Rosendale cements has lately engaged my attention, but before setting forth the results obtained I will recall briefly the history of our modern knowledge of cement.

The monuments of Egypt present one of the oldest examples of the use of lime for constructions. The mortar which joins the stone of the Pyramid of Cheops is precisely similar to modern mortars made of sand and lime. In limiting the use of mortar to filling narrow joints which separate immense blocks, and thereby reducing almost to insignificance the part which it had to play, the Egyptians seemed to forestall the influence of a dry and burning climate. Time has justified their prudence in this respect, for the works erected on the banks of the Nile by the Romans, made of small materials and presenting many joints, have left but faint traces, whilst some Egyptian temples still present themselves intact to our admiration.

Unqualified praise has often been given to the excellence of Roman mortar, and the belief is sometimes expressed that all we can hope to do is to regain the secret of making mortar once possessed by the Romans. It is a common remark that "Roman mortar has lasted for eighteen centuries, whilst a number of modern buildings are in a deplorable state of preservation."

To make a fair comparison, we should, however, only cite similar constructions, and then we are comforted by these words of Pliny: "The cause which makes so many houses fall in Rome, resides in the bad quality of the cement."

* From the Proceedings of the American Society of Civil Engineers.

The knowledge of the properties of lime descended from Egypt to Greece, where the exigencies of the climate and the ingenuity of the people brought forth many of its uses, unknown to Egypt.

Subsequently Greek colonies imported and popularized their processes in Italy; and Roman architects, like Vitruvius, cite the names of Greek authors on the art of construction. Their names alone have come down to us, but Vitruvius had full access to them, and in our inquiry after the knowledge of mortar possessed by the Romans, it is to him that we must refer for information. Indeed, he has left us a detailed table of precepts used by the builders of Greece and Rome, which do not justify our unreserved admiration; everything relating to lime, sand and pozzolana is clearly treated therein.

We may safely affirm, with Vitruvius, that the Romans made use of the lime, sand and materials of the countries where they built; that they considered the best lime to be produced from hard and pure marble, *i. e.*, the fattest lime known; that in Italy they mixed it with pozzolana when used for hydraulic purposes, and that out of Italy they replaced the pozzolana from Vesuvius, by powdered brick or tile.

Roman mortars, when examined to-day, are found to bear a distinct resemblance to each other; they may be recognized by the presence of coarse sand mixed with gravel; lumps of lime are so often to be met with, that incomplete slaking will alone account for them. Mortars laid in damp spots for cisterns and pavements were composed of bricks in small fragments mixed with fat lime; this concrete required to be compacted by pounding and left to dry—the surface was then scraped, polished and painted—evidently to prevent the dissolution of lime by water.

It will be seen by this that what we term hydraulic lime, and also the modern product of cement, were unknown to the Romans.

It is important to refute the belief that methods may have been known to them of which we have lost the secret. When the decay of arts followed upon the downfall of the Roman Empire, houses nevertheless continued to be built, and the familiar processes under the eye of the workman must have been transmitted from father to son. So true is this, that to-day Italian masons, who certainly have not read Vitruvius, make coatings for cisterns and concrete floors in the very same manner as may still be seen in the ancient ruins of Rome.

Neither is it true that Roman mortar is uniformly good. Its strength of cohesion varies in different examples from 35 and 85 lbs. per square inch to 100 and 160 lbs., or as much as 500 per cent.

In the middle ages a volcanic conglomerate from the banks of the Rhine, named traass, was substituted for the pozzolana of Italy, and mortar was made of fat lime, mixed with traass, to render it hydraulic. Many castles erected during that period stand well to-day; the well-known castle of the Bastile, erected in 1369–83, which after withstanding a siege required the use of powder for its destruction in 1789, was found to be extremely solid even in the interior walls.

It would seem, then, that the secret of the Romans was known also in those times, and could have been lost only at the Renaissance, when least of all such a supposition is probable.

At what period were first used certain limestones, having the property of producing a lime which will harden under water, is not precisely known; the first use of cement stone is equally obscure.

In 1796 Messrs. Parker and Wyatts began to manufacture from egg-shaped limestones found near London, a product known later as *Roman Cement*, and which was soon received with great favor throughout Europe; but neither the producers nor the consumers offered any explanation of its merits.

Not until 1818 and the following years was the true explanation given of the hydraulic properties of limes and cements, when Vicat published his discoveries.

Before that, in 1756, when Smeaton was preparing the arduous and bold construction of the Eddystone Lighthouse, this celebrated engineer examined with scrupulous attention the natural hydraulic lime of Aberthaw. Treated by acids it left a residue "which appeared to be a bluish clay, weighing about one-eighth of the total weight of the stone."

In 1786, Saussure attributed the hydraulic properties of some limes of Savoy to the combined influence of manganese, quartz, and even clay; but he left his opinions in the mere state of conjectures.

Finally, Descostils, in 1813, having discovered a considerable proportion of finely divided silica in the lime of Senonches, attributed the well-known hydraulicity of that lime to the silica it contained.

But the conjectures of Smeaton, of Saussure and of Descostils were vague; they rested upon no proofs, and found no applications in practice.

The discoveries of Vicat attained their immediate object, for in a short time artificial hydraulic lime of excellent quality was manufactured on a large scale under his direction, and a few years later he indicated as many as 400 quarries in France where hydraulic limestones were to be found.

Moreover, the mortar made from his hydraulic lime equalled in hardness at the end of eighteen months the hardest ancient Roman mortars.

It is unnecessary to recall the evidence by which Vicat demonstrated —by analysis and by synthesis—his great discoveries. No one questions to-day the fundamental truth, that the properties of hydraulic limes depend upon the proportion of clay disseminated throughout its tissue, and that clay by being calcined acquires the property, like pozzolana or traass, of rendering fat limes hydraulic, when thoroughly diffused throughout their mass.

The labors of Vicat and Berthier have led to the following classification of limes and cements, and consequently of limestones and cement-stones:

Table of Classification of Limes and Cements.

Proportion of clay in the limestone.	Proportion of clay in the product.	Class of lime or cement.
Less than 10 per cent.	Or less than 17 per cent.	Fat and non-hydraulic limes.
From 10 to 15 "	From 17 to 24 "	Slightly hydraulic limes.
" 15 to 17 "	" 24 to 27 "	Hydraulic limes.
" 17 to 20 "	" 27 to 30 "	Eminently hydraulic limes.
" 20 to 23 "	" 30 to 34 "	Limit of hydraulic limes.
" 23 to 30 "	" 34 to 43 "	Beginning of cements.
" 36 per cent.	" 50 per cent.	Good hydraulic cements.
" 40 per cent.	" 54 per cent.	Hydraulic cements of diminishing value.
" 60 to 90 per ct.	" 73 to 94 per cent.	Pozzolanas.

A point which bears directly upon our subject is the fact of the existence of a limit for the proportion of clay, at either end of the scale of cements. The transition from the properties of hydraulic lime to those of cement is not gradual, but sudden. Thus a limestone containing 20 per cent. of clay will produce an eminently hydraulic lime, but if we increase this proportion to 23 per cent., it is neither a hydraulic lime nor a tolerable cement that we have, but a worthless product, which if submerged will remain for days and even weeks without giving any sign of slaking, and then crumble away insensibly without effervescence; or if pulverized and tempered like plaster, will give an appearance of setting, but crack and turn into mud when submerged.

These products, which may be called the intermediate limes, are found on an average between 20 and 23 of clay for 100 of limestone;

but these numbers are not absolute, for some limestones containing 21 and 23 per cent. of clay make both good hydraulic lime and cement, and also the former when underburnt give very irregular results, forming sometimes a cement and at others a worthless compound.

In the same way there is a superior limit to the proportion of clay in cement, which when surpassed gives a poor cement. The exact position of this superior limit is not entirely agreed upon. It is placed at 36 per cent. and sometimes 40 per cent. by Vicat, and at 40 or 46 per cent. by Berthier.

The composition of the layers forming the quarries from which the Rosendale cements are taken is extremely variable, the proportion of clay ranging from 15 per cent. to 47 per cent. Some of these layers contain the right proportion of clay for good hydraulic limes, and for cements, while others contain the proportions which correspond to the intermediate limes and the superior limit of cements. The separate layers are not entirely uniform in their composition, and, like all beds of limestone, those situated near the surface lose a portion of their carbonic acid by the alternate action of heat and moisture.

Therefore, if the stones obtained from the different layers be mixed according to color and physical appearance, as is sometimes practised, and without a due regard to the exact chemical composition of each, it is obvious that uniform and good results are not likely to be obtained.

I am unable to give at present the result of the analysis of more than four of the different brands of Rosendale cement which I have examined, and, the labor being incomplete, I refrain for the present from naming the brands which have been analyzed.

The following are the results:

Analysis of Cement No. 1.

Water,	1·2 per cent.		
Carbonic acid,	traces.		
Silica,	30·7	per ct.,	or as 43·6 per ct. of clay to 56·4 per ct. of lime and magnesia.
Alumina and sesquioxide of iron,	12·0		
Lime,	42·6	per ct.,	
Magnesia,	12·8		
Total,	99·3		

Analysis of Cement No. 2.

Water,	0·2 per cent.
Carbonic acid,	traces.

Silica,	33·	per ct.,	or as 46 per cent. of clay to 54 per ct. of lime and magnesia.
Alumina and sesquioxide of iron,	13·		
Lime,	33·	per ct.,	
Magnesia,	20·		
Total,	99·2		

Analysis of Cement No. 3.

Water,	0·5 per cent.		
Carbonic acid,	traces.		
Silica,	27·	per ct.,	or as 37 per cent. of clay to 63 per ct. of lime and magnesia.
Alumina and sesquioxide of iron,	10·0		
Lime,	50·3	per ct.,	
Magnesia,	12·		
Total,	99·8		

Analysis of Cement No. 4.

Water,	0·2 per cent.		
Carbonic acid,	traces.		
Silica,	31·6	per ct.,	or as 40 per cent. of clay to 60 per ct. of lime and magnesia.
Alumina and sesquioxide of iron,	7·8		
Lime and magnesia,	60·	per ct.,	
Total,	99·6		

These results show that the Rosendale cements above examined contain a proportion of clay which approaches, in some cases, to the proportion indicated by Vicat as forming the best cement, and in others to a proportion nearer the beginning of the scale of cements.

A point worthy of notice is, that if we compare these cements to the English and French cements, the one marked No. 3 contains nearly the same proportion of clay as the French Portland; No. 4 contains the same as the cement of Vassy; Nos. 1 and 2 contain more clay, although nearer the proportions named by Vicat for the best cements, and all contain more magnesia than is common to European cements.

The cements examined also contain traces of alkalies and chlorides. One contained $\frac{7}{1000}$ of sulphate of lime, which is not to be considered injurious, as it does not exceed three per cent.

The large proportion of magnesia in these cements is remarkable.

Chemists are not wholly agreed upon the effects of magnesia in the presence of lime.

Magnesia in the presence of silica and alumina is known to form crystallizations which resist the action of sea water better than lime —and Vicat remarks that the presence of magnesia exalts the quality of cement for marine uses.

On the other hand, it is equally certain that the silicate of magnesia crystallizes slower than the silicate of lime, and Rigot asserts that the consequence of the presence of magnesia is disaggregation, or at least inferior hardness.

In the presence of these conflicting opinions, the true influence of magnesia remains a subject for investigation.

Having but recently analyzed various American limes and cements, I am not able to present comprehensive or complete results, and my object in introducing the subject at this stage is to call the attention and invite the labors of others, in completing the studies required for the uniform production of the best quality of hydraulic limes and cements. But my inquiries have gone far enough to convince me that standard cements will not result from experimental mixtures, not guided by selections based upon accurate analysis.

I conclude with the following analysis of Rockland lump lime:

Water and carbonic acid,	traces.	
Silica,	5·6	per cent., or 7·8 per cent. clay.
Alumina and sesquioxide of iron,	2·2	
Lime,	87·6	per cent., or 91·9 per cent. lime and magnesia.
Magnesia,	4·3	
Total,	99·7	

Gilding Iron.—The employment of sodium amalgam is recommended by Kirchmann as a simple and effective means of covering iron with a gilded surface. The process, in brief, consists in first spreading the amalgam upon the surface of the metal, which at once coats itself with a layer of quicksilver, even though it may be somewhat rusted. Upon the surface thus prepared a concentrated solution of chloride of gold is poured and the mercury volatilized by heating before the lamp or in a furnace. The result is that a gold surface remains behind which is susceptible of a bright polish. With silver and platinum, it is said, similar results may be obtained.

Franklin Institute.

Proceedings of the Stated Meeting, October 16, 1872.

The meeting came to order at the usual hour, with the President, Mr. Coleman Sellers, in the chair.

The minutes of the last meeting were read and approved.

The minutes of the last meeting of the Board of Managers, held October 9th, were read by the Actuary, and approved.

The Actuary also submitted the following list of donations to the Library for the month of September, to wit:

A series of Specifications of English Patents for the years 1869, 1870 and 1871, from the Hon. Commissioners of Patents: Annales des Ponts et Chaussées, from the Director of Roads and Bridges, Paris. The American Vine Dresser's Guide, from Alphonse Loubat. The Geological Survey of Ohio, with maps, from J. S. Newbury, State Geologist. A Discussion of the Meteorology of that part of the Atlantic lying north of the 30th parallel (north) for the eleven days ending February 8th, 1870. From the Meteorological Committee of the Royal Society, Wabbs of Venis, prepared for the use of American Ephemeris and the Nautical Almanac. From the Chief of the Bureau of Navigation, Washington, D. C. Proceedings of Academy of Natural Sciences, Philadelphia, from the Society.

The President of the Institute then announced that the evening of the October meeting had been especially set apart for the purpose of discussing the reports of the Committee on the Horse Power of Boilers, but added the following remarks:

It is my painful duty to announce to you this evening the death of a prominent member of this Institute. On Saturday, the 12th inst., Professor John F. Frazer departed this life, in a sudden, and for aught I know, entirely unexpected manner. Of the sad incidents connected with that event, you are all doubtless familiar, but it is eminently fitting that mention be made at this time of the part played in the history of the Institute by one who has done so much to advance its interests during a period of thirty-seven years. In 1835, Prof. Frazer was elected a member of this Society. From the very first, he was active on committees and in all the scientific investigations undertaken by the Institute; prominently so in all that related to steam boilers and steam boiler explosions. In 1841, he was elected Corresponding Secretary, and was chosen Treasurer in 1848—an office which he held until 1864, a period of sixteen years. Elected Vice-President in 1865, he was forced to resign in 1866, on account of ill health. He was an active member of the Committee on Instructions in 1845,

and Chairman of that important committee until 1866. In 1850, he took formal charge of the JOURNAL of the Institute, and continued to act as its editor until 1866. I feel confident that there are amongst those who hear me this evening, friends of Prof. Frazer, who are much better fitted to speak of his merits than myself—friends who have known him longer and more intimately than I have; but I think there are none who have a higher opinion of his worth, or who regret his death more deeply. From my earliest connection with the Franklin Institute, up to the time when failing health caused him to withdraw from active life, all my recollections of its scientific and practical workship are in some way associated pleasantly with that large-hearted man. Very learned and endowed with an astonishingly retentive memory, he was ever ready to give from his abundant stores of knowledge freely to others. He was ever earnest in his advocacy of right, and ever bold and outspoken in his denunciation of wrong. I saw him on Friday last, seated in the chapel of our great University, taking part in the ceremonies of dedications. I thought of him then as I looked at him, as the oldest member of the distinguished faculty of that old school of learning. It is so sad, so very sad, to think that at the very beginning of a new era in University education in America, so brilliant and useful a member has been taken away.

Upon the conclusion of the President's remarks, Dr. R. E. Rogers, in a few expressive words of deep regret, moved that Mr. Frederick Fraley, who had been so long associated with the deceased in the work of the Institute, be appointed to frame suitable resolutions upon the sad event, expressive of the sentiment of the Society. The motion was carried.

The President then announced the business of the evening to be in order, namely—the discussion of tho report of the Committee on the Horse Power of Steam Boilers. The reports were read by the Secretary, and the Chairman of the Committee inaugurated the discussion by some lengthy remarks, defining the origin of the Committee, its labors, and advocating the adoption of some standard of rotary boilers by the Institute. He was followed by Mr. Robert Briggs, and the discussion finally was participated in by Prof. R. E. Rogers, Wm. B. Le Van, Lovegrove, S. L. Wiegand and other members, and will be found in full in the Journal of the Franklin Institute, vol. lxiv, page 377.

The Secretary next read a brief report upon Current News, and the meeting was, upon motion, adjourned.

W. H. WAHL, *Secretary.*

Proceedings of the Stated Meeting, Nov. 20th, 1872.

The meeting was called to order by the President, Mr. Coleman Sellers.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and reported that at their Stated Meeting, held November 13th, the following donations had been received into the Library:

The thirty-ninth Annual Report of the Royal Cornwall Polytechnic Society, 1871, from the Society. From a member, Recent Practice in the Locomotive Engine: being a supplement to Railway Machinery, by Daniel Kennea and Zerah Colburn. From the Hon. Secretary of the Navy, papers relating to the Transit of Venus in 1874. From the American Philosophical Society, their proceedings from January to June, 1872. From the Zoological Society of London, their proceedings for 1872, with a Catalogue of their Library. From the Academy of Sciences of Paris, "Comptes Rendus Hebdomadaires des Seances de l'Academie des Sciences," from April to July, 1872. From the Institute of Civil Engineers of London, England, "Minutes of Proceedings," Vols. 33 and 34. From the Chemical Society of London, their Journal for May, June and July, 1872. From the Society of Arts, of London, 9 vols. of their Journal, from Aug. 2d, 1872, to Sept. 27th. From the Statistical Society of London, Vol. 35, Part 3d, of their Journal. From the Society for the Encouragement of National Industry, of Paris, their "Bulletin" for August and September, 1872. From the Academy of Sciences, Comptes Rendus Hebdomadaires des Seances, from July to September, 1872. From the Literary and Historical Society of Quebec, their Transactions of the Session of 1871–72. From the Academy of Natural Sciences, of Philadelphia, Part 2nd of their Proceedings, from May to September, 1872.

Mr. Frederick Fraley then, upon request, presented the following Resolutions upon the death of Prof. J. F. Frazer, which were unanimously adopted:

Resolved, That the Franklin Institute, in recording upon its minutes the sudden and lamented death of John F. Frazer, LL. D., is called upon by a high obligation of duty to acknowledge the manifold services he rendered as a member, officer and professor, and to express its sense of his character and worth as a citizen and friend.

Resolved, That it is with great pride we feel that we can claim him as a scientific man, made so to a great extent by the Institute, to which he attached himself in early life, and by his hearty co-operation in the labors of its founders and friends, greatly aided in raising it to the high rank which it now enjoys.

Resolved, That the services of Prof. Frazer in the Chair of Chemistry, as Editor of the Journal, as a member of many important committees on science

and the arts, and as a liberal and devoted friend, always ready with heart, head and purse, to promote the interests, welfare and reputation of the Institute, will ever be held in grateful remembrance by its members.

Resolved, That it is with deep sorrow we mourn the loss of one who has filled so important a part in the history of the Institute, but trust that his example may have many followers, and that, emulating his manly, chivalric and ingenuous career, they may love it as he did, and faithfully and fearlessly carry forward all its aims for the promotion of the mechanic arts, and technical education.

Resolved, That we sincerely sympathize with his family in their great bereavment, and that the President of the Institute be requested to forward to them a copy of these resolutions as our tribute of love and respect for one so worthily endeared to them.

The President next announced, in appropriate terms, the death of Mr. John Agnew, dwelling upon his life-long connection with the Institute, and requested Mr. Frederick Fraley, who had been associated with the deceased in the working of the Institute longer than any other member, to address the Institute in relation to the character and services of Mr. Agnew. Mr. Fraley responded with a lengthy, extemporaneous eulogy of the deceased, which he was requested to prepare suitably for entrance on the minutes of the Society.

The President next announced a description by Mr. J. E. Mitchell of a new tool for turning and dressing grindstones.

Mr. Mitchell was followed by Mr. G. M. Eldridge with a paper on a new device for securing circulation in steam boilers, &c., in which it is asserted that with a model constructed for the purpose of experiment, the evaporation had been increased 50 per cent.

Mr. Hector Orr next presented a paper on the premature decay of timber, which was suggested by an examination of the wreck of the steam frigate Chatanooga. The paper elicited an extended discussion, which was participated in by Messrs. Close, Fraley, Sellers, Durfees, Eldridge and Orr, and is published in the Journal of the Institute, Vol. lxv, page 55.

The President next announced the addition of the following named gentlemen upon the committee to determine the mode of estimating the horse power of steam boilers, viz: Lloyd S. Wiegand, Prof. R. E. Rogers, and Thomas L. Souders.

The meeting was then, upon motion, adjourned.

W. H. Wahl, *Secretary.*

Proceedings of the Stated Meeting, Dec. 18, 1872.

The meeting was called to order by the President, Mr. Coleman Sellers.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at their Stated Meeting, on December 11th, the following donations to the Library had been received.

From Prof. J. H. C. Coffin, U. S. N., The American Ephemeris, and Nautical Almanac for the year 1873. From the Chemical Society, of London, their Journal for August, September and October, 1872. From the Society of Arts, of London, their Journal for October, 1872.

The Secretary next read, at request of the President, the following resolutions of respect to the memory of the late Vice-President of the Society, Mr. John Agnew, prepared and offered for approval by Mr. Frederick Fraley, which were unanimously adopted:

Resolved, That the members of the Franklin Institute, affectionately cherishing the long and faithful services of JOHN AGNEW as a member and officer of the Institution, desire to place permanently on its records their high appreciation of his worth and virtues.

Resolved, That the example furnished to our mechanics and workingmen of all classes by the long and useful life of Mr. Agnew, is one eminently worthy of imitation, and has been of great utility to the Institute, and the public generally, showing how much may be accomplished by earnestness and zeal, unaided by early advantages of education, social position, or wealth.

Resolved, That it is a source of great pleasure and thankfulness on the part of the members of the Institute that, during the whole course of a life protracted beyond the ordinary limits allotted to many, John Agnew was permitted to give his time and talents to the promotion of the great objects of the Franklin Institute by associating himself with it as an original member, and for nearly half a century devoting himself and his energies to its success and welfare.

Resolved, That while we sincerely condole with his widow and his friends generally in the bereavement caused by his death, our regret for his loss is softened into rejoicing by the conviction that his quiet translation from earth has been to a final resting place of eternal rest and happiness.

Resolved, That the President be requested to transmit a copy of these resolutions to the widow of Mr. Agnew.

The President next announced the paper for the evening to be by Mr. Samuel Webber, on the construction and use of the "Francis' Dynamometer." The paper attracted considerable discussion, which was participated in by Messrs. Nystrom, Webber and the President, and will be found published in full in the Journal of the Institute for February, 1873.

The Secretary next read his monthly report upon novelties in Science and the Mechanic Arts.

The President then announced that the evening was fixed by the By-Laws of the Society as the time for nominating officers of the Society for the coming year. It was then, upon motion, resolved that nominations for officers be opened. The following were thereupon nominated for the offices opposite their names.

President.—Coleman Sellers.
Vice-President.—Henry G. Morris.
Treasurer.—Frederick Fraley.
Secretary.—William H. Wahl.

To serve as *Managers* of the Institute:

For two years.—F. B. Miles, J. E. Mitchell.

For three years.—William Sellers, J. V. Merrick, B. C. Tilghman, Hector Orr, John H. Cooper, Henry Cartwright, Henry W. Bartol, Theodore Bergner.

To serve as Auditor for three years.—James H. Cresson.

The President then announced the appointment of the following gentlemen to serve as judges of election upon the day of election.

George Gardom, Wm. A. Rolin, M. W. Haines, Theodore D. Rand, William Biddle, Samuel Sartain, John W. Nystrom.

The meeting was then, upon motion, adjourned.

Wm. H. Wahl, *Secretary.*

Aniline Powder.—Amorphous silica has been found to possess a great absorbing power for colors, and especially for the anilines.

Upon agitating precipitated and well-washed silica with a solution of fuchsine, aniline blue, or violet, the silica is strongly colored, and in this way powders may be obtained which may be applied to a variety of purposes in the arts. It is possible to attach the aniline colors with great permanency to cotton goods, by first impregnating them with silica and subsequently applying the dye.

The method consists in first steeping the goods in a solution of water glass, then precipitating the silica upon the fibre in a very finely divided state, by passing the goods through an acid bath, and then to bring them into the dye bath.

Experiments have been even made by M. Riemann to fix anilines upon glass, by mordaunting with hydrofluoric acid, though with what result is not made public.

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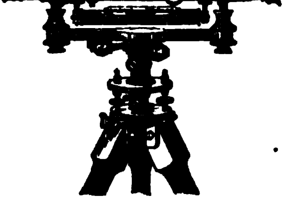

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C. LAFLIN, President, Westfield, Mass.

G. L. LAFLIN, Secretary and Treasurer, Westfield, Mass.

G. S WHITNEY, Secretary and Treasurer, Mount Morris.

SEE on another page, advertisement about *Iowa and Nebraska Lands.*

THE BOYDEN PREMIUM.

URIAH A. BOYDEN, ESQ., of Boston, Mass., has deposited with the Franklin Institute the sum of one thousand dollars, to be awarded as a premium to

"Any resident of North America who shall determine by experiment whether all rays of light, and other physical rays, are or are not transmitted with the same velocity."

The following conditions have been established for the award of the premium:

1. Any resident of North America, or of the West India Islands, may be a competitor for the premium; the southern boundary of Mexico being considered as the southern limit of North America.

2. Each competitor must transmit to the Secretary of the Franklin Institute a memoir, describing in detail the apparatus, the mode of experimenting, and the results; and all memoirs received by him before the first day of January one thousand eight hundred and seventy-three, will, as soon as possible after this date, be transmitted to the Committee of Judges.

3. The Board of Managers of the Franklin Institute shall, before the first day of January, one thousand eight hundred and seventy three, select three citizens of the United States, of competent scientific ability, to whom the memoir shall be referred; and the said Judges shall examine the memoirs and report to the Franklin Institute whether, in their opinion, and, if so, which of their memoirs is worthy of the premium. And, on their report, the Franklin Institute shall decide whether the premium shall be awarded as recommended by the Judges.

4. Every memoir shall be anonymous, but shall contain some motto or sign by which it can be recognized and designated, and shall be accompanied by a sealed envelope, endorsed on the outside with same motto or sign, and containing the name and address of the author of the memoir. It shall be the duty of the Secretary of the Franklin Institute to keep these envelopes securely and unopened until the Judges shall have finished their examination; when, should the Judges be of opinion that any one of the memoirs is worthy of the premium, the corresponding envelope shall be opened, and the name of the author communicated to the Institute.

5. Should the Judges think proper, they may require the experiments described in any of the memoirs to be repeated in their presence.

6. The memoirs presented for the premium shall become the property of the Franklin Institute, and shall be published as it may direct.

SEE on another page, advertisement about *Iowa and Nebraska Lands.*

Contents for February, 1873.

Illustrations—Five Plates and Five Woodcuts.

Published Monthly. Price, $5 per annum, in advance.

THE

JOURNAL

OF THE

FRANKLIN INSTITUTE

DEVOTED TO

SCIENCE AND THE MECHANIC ARTS.

EDITED BY

WILLIAM H. WAHL, PH. D.

ASSISTED BY THE COMMITTEE ON PUBLICATIONS.

Vol. XCV.—No. 567.

THIRD SERIES.

Vol. LXV.—APRIL, 1873.—No. 4.

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1872.

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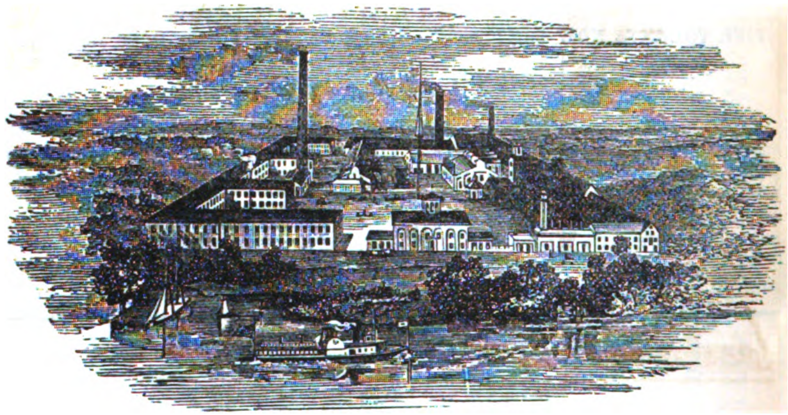

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THE JOURNAL

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(Established 1826.)

DEVOTED TO SCIENCE AND THE MECHANIC ARTS.

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JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA.

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LXV.] APRIL, 1873. No. 4

EDITORIAL.

ITEMS AND NOVELTIES.

The Worcester County Free Institute of Industrial Science.—*With Remarks on the Technical Education of Mechanics.*—By COLEMAN SELLERS, President of the Franklin Institute.—It is my desire to call your attention this evening to an ingenious and convenient form of drawing-table or desk, the work of the students of the Worcester County Free Institute of Industrial Science. It is so arranged as to be readily adjusted in inclination of surface, while a shelf or ledge for the reception of drawing instruments, inkstand, or the like is so hinged to the table, and controlled by a bar or rod of iron below, as to maintain its horizontal plane in whatever inclination the drawing-table is placed. Beneath the shelf are drawers for the reception of drawing instruments. The attachment to the tripod is so made as to permit an adjustment of height to suit the convenience of the workman, and a clamping-screw in a collar permits the table to rotate on its centre support or be rigidly fixed in any required position. Thus you see it can be used as a high or low desk and a high or low table. It can also be so placed as to serve the purpose of a painter's easel. In the library it is a most useful piece of furniture.

As an easel it may be used to display a picture or engravings. As a table it is a convenient support for the microscope, and its ready elevation makes it useful to carry a spectroscope. These are the uses to which I expect to apply this table. Thus you see it is one of those very convenient pieces of furniture that when once tried becomes an indispensable luxury. It fills a want long felt, and its cheapness brings it within easy reach of all. Apart from its mechanical excellence, however, I feel a deeper interest in its makers. I have said it is the work of students in an industrial school. A few words about this school, its aim and method of working, may not be amiss in an Institute whose whole effort has been to promote the mechanic arts.

Fig. 1

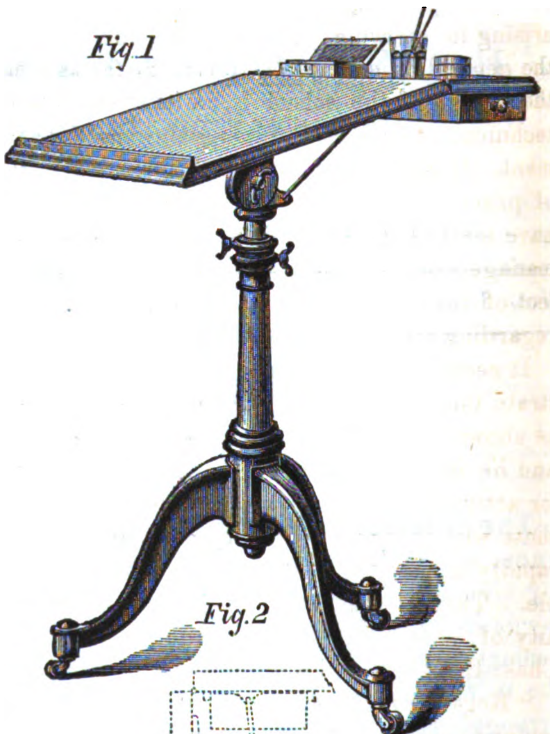
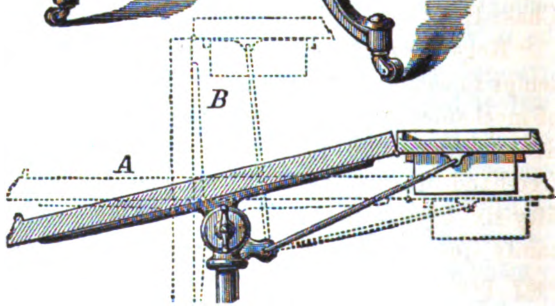


Fig. 2



This school was founded by one John Boynton, in the year 1865. To his gift of one hundred thousand dollars, other liberal citizens added various sums, until a school was established on a firm basis. In the year 1866, the Hon. Ichabod Washburn conceived the idea of adding "a machine shop of sufficient capacity to employ twenty or more apprentices, with a suitable number of practical teachers and workmen in the shop to instruct such apprentices, and provided with all necessary steam-power, engines, tools,

apparatus and machinery, of the most improved models and styles in use, to carry on the business of such machine shop in all its parts as a practical working establishment," his wish being that the apprentices entered should have as good a chance to become proficient workmen as if brought up in any of the best workshops, with the addition of some mental training. In the deed of gift Mr. Washburn made the wise provision that in event of any insurmountable difficulties arising in carrying out the plans, the money might be merged into the general fund of the Institute. So far as I have been able to learn, the design of the school is, in its scope and purpose, much like the technical schools of Europe, giving prominence to the practical element. It is not my intention this evening to review the entire course of practice and studies, but rather to draw your attention to what I have learned in regard to the management of these apprentices. The managers of the school, knowing the interest I have taken in the subject of the education of mechanics, have given me much information regarding the theory of its operation.

It seems that a five months trial is deemed sufficient to demonstrate the fitness of any student to pursue the mechanical career; if he shows too little mechanical talent, his true bent may be discovered, and he is then transferred to such department as may best fit him for active life; so that the non-mechanics become weeded out, and those who continue are the more careful. The boys are advanced as rapidly as possible, and are freed from drudgery as soon as practicable. They are taught habits of industry, and made to feel the dignity of labor. Free-hand drawing is an imperative necessity. Mr. Chas. H. Morgan, in a letter under date March 10th, 1873, says:

"Regarding our school, I may say that it is successful in its attempt to combine theory and practice, especially in the department of mechanics. The students in this department are required to have five months (solid) practice, except ten hours each week devoted to free-hand drawing before commencing studies. We have at present fifty-six boys in the shop and only six journeymen. You will certainly question how we manage so many boys, and we found it no easy problem. In answer, I have to say that we have found it for their advantage and to the success of our shop, to employ them at wood work for the first year, in making small articles that require but little material; the time is well spent, and we gauge their capacity at the least expensive work, and we find that boys make quite as much advancement in working iron during the term for having had

this practice in the wood shop. The drawing table is the work of students; they also make models for drawing. The senior class work on the speed and engine lathes." The machine tools turned out by the students are said to be well made. The boys entering the shop find workmen employed producing work for sale; they are employed at such parts as they can do to the best advantage, and their work is sold, but they receive no wages. Mr. Washburn did not believe such a shop could be made self-supporting, and he provided for this contingency by the interest of a fund of $50,000.

"With all these advantages the work done by the apprentices is hardly an adequate compensation for the expense involved in instruction." I understand that the object of the superintendent is to maintain the highest standard of workmanship practicable, and as the aim is to teach, not to make money, it becomes possible, by judicious management, to employ usefully nine apprentices to one journeyman.

The business of the shop amouuts to about ten thousand dollars annually. The profits with the income of the endowment fund have so far just equalled the expense of operating it. It is claimed that the element of personal responsibility enters with every student's work, and all mere turning of material from one form into another for the sake of observing the process, is avoided. Two classes have been carried through the three years' course, and are successful as journeymen and as draftsmen in first-class machine shops. Students intending to take the course of mechanical engineering must begin their apprentice course five months sooner than any other class of students, and these five months are sufficient to enable the superintendent to determine the fitness of the student for the profession, and then, in case they have no aptitude for mechanics, they can enter the full term as civil engineers, or in architecture, drawing and design; in chemistry, or in English, French and German, certain studies being common to all these departments, as it is the aim of the institution to give as complete a general education as possible, and to point out the true relations of theory and practice. The course of study covers three years—senior, middle and junior.

There seems to me much that is good in this experiment in American education. No three years in school or in workshop can turn out proficient mechanical engineers. It can only start them in the right road to reach the goal. But any system that will give us educated mechanics accomplishes something in the right direction. It is from our stock of educated mechanics that we must hope to draw our na-

tion's future prosperity. Skilled workmen are in demand, but if we depended upon our skilled laborers alone, we would soon fall behindhand. Well directed ingenuity, however, takes the place of skill, enabling unskilled workmen to produce new and better work than skill, unaided by machinery. The scythe and cradle drove the sickle out of the harvest field; but where are the mowers of this vast continent? happily, a boy on a mowing machine can do more and better work than many skilled reapers and mowers.

The skilled mechanic of by-gone days could do marvels with his chisel and file, but the planing machine and scraper have already almost numbered his trade with the lost arts. The skilled workman of to-day may in a few years find no use for his handicraft; but if he to his skill has added a well-stored mind, he becomes invaluable; for it is from the progressve mechanics that we draw our stock of foremen and leaders. Good judgment, ingenuity, knowledge of what has been done by others, with moderate skill, is what is needed; and when to these we add general mental culture, the happy possessor is more sure of success in life than any others who have not been born with silver spoons in their mouths. For in these days of iron and of railroads, the educated mechanic is in demand.

Philadelphia stands to-day the greatest manufacturing city of this continent. In its 8339 establishments, well nigh $200,000,000 worth of machinery is adding its products to the commerce of the country, and yet among all this hum of busy industry, with a full knowledge that it is far better that our sons shall have good trades to fall back on, after their school-days are past, the problem of what is best for their future is pressing on each one of us daily. It is impossible for all the boys who desire to enter the workshops in this city to find employment. There is a limit to the amount of apprentice labor fixed by possibility of profit to the employers. Hence schools such as this at Worcester, if successful, must be of great use. And any system of education that to mental culture adds manual skill and impresses the student with the fact that there is dignity in manual labor, and that implants in him habits of industry and frugality, is to be encouraged. Feeling the importance of the subject, I have been induced to make this convenient little table an excuse for barely touching on a subject of so much interest to every parent or guardian. Having thought much on this subject, I hope at no very distant day to be permitted to present to the Institute a more carefully prepared paper on the technical education of the American mechanic.

A Huge Band Saw.—The Journal noticed, some time ago, that a band saw of unprecedently large proportions was in course of building, for Mr. J. J. Van Pelt, of New York, at the establishment of Messrs. Richards, London & Kelly, of Philada.

The machine was delivered some time ago, and has been for some months in successful operation, at the mills of the gentleman above named.

The dimensions of the machine are as follows: Saw, 55 feet long, 4½ to 6 inches wide and of 16 gage; manufactured by Perin & Co., Paris.

The pulleys are 75 inches in diameter, including hubs of wrought iron, and are mounted centrally on the main column, so as to equalize the strain of the saw, and prevent its springing, and to economize its weight.

They are covered with a lagging of pine, over which is glued an envelope of heavy harness leather.

The bearings for the wheel shafts are four inches in diameter, and twelve inches long, and are made of an alloy of 6 parts of copper and one of tin. The tension is from one to four tons, and necessarily calls for the greatest rigidity in the framing to prevent the guides from being thrown out of position by the varying tension of the blades.

The kerf of the saw is said to be less than that of a circular saw. Speed is 4,500 feet per minute. Pine timber can be cut at the rate of sixty feet, and oak and yellow pine at the rate of thirty feet per minute, the logs being from one inch to five feet in thickness.

It is said that the saw will follow the curvature of long timber, such as is used in ship building, and is cut with the grain. This property not only effects considerable economy in the timber over the circular saw, but also adds to the value of the work.

The experiment is declared on all sides to have proven a complete success; and will doubtless lead to others no less novel.*

The Steam Jacket.—Before the Scientific and Mechanical Society of Manchester, England, the subject of the steam jacket, its advantages and disadvantages and economy were discussed, and some interesting differences of opinion manifested. Wm. A. Hildebrandt maintained the assertion that the use of the steam jacket was opposed to economy. He stated his position as follows: Its advantages are,

* Sci. Amer., March, 1873.

1st, that it slightly increases capacity of the cylinder, by keeping the steam within dry; 2d, it affords greater immunity from breakdowns, since it prevents the accumulation of condensed water in the cylinder. Its disadvantages were thus stated: 1. Waste of fuel. 2d. Increased labor in its attendance. 3d. Increased outlay of capital, amounting to about 20 per cent. From this presentation, Mr. H. pronounces the judgment that the steam jacket must be declared to be not economical. In the discussion which the paper elicited, several prominent engineers expressed themselves strongly in favor of the jacket; others as strongly against it. One member, for example, states that from careful observations for several months, upon an engine with a steady load, he found that by discontinuing the use of the steam jacket a saving of 10 per cent. of fuel was effected.

Increase of Iron Works in 1872.—The following tabulation from a contemporary will serve to give a tolerably clear estimate of the progress of the iron industry of the country.

STATE.	FURNACES.		ROLLING MILLS.		TOTAL.
	Built.	Projected.	Built.	Projected.	New Works.
Pennsylvania,	48	11	15	5	79
Ohio,	13	6	7	4	30
W. Virginia,	1		1		2
Indiana,	4	1	2	1	8
Illinois,	3		4		7
Missouri,	6	2	1		9
Tennessee,	5	2	1		8
Wisconsin,	8				8
Michigan,	6	5	1		12
Massachusetts,	1		1		2
New York,	4	1	2		7
Vermont,			1		1
Connecticut,	1				2
New Jersey,	1				1
Georgia,	2	7			9
Alabama,	2			1	3
North Carolina,	1	4			5
Total,	107	39	36	12	194

Iron Production.—In connection with the foregoing statement of the progress of the iron industry of the country, the following abstract from the report of the secretary of the Pig Iron Manufactur-

ers' Association may be of interest. From this document we glean the information that the make of iron during the year 1872 amounted to 2,388,250 tons; divided as follows:—Anthracite, 1,197,010 tons; raw bituminous and coke, 712,500 tons, and charcoal, 478,500 tons.

From an inspection of the table above given, it appears that the increase in the number of rolling mills has kept pace with the number of blast furnaces.

There was consumed in the country during the year, 4,054,618 tons of iron, including 400,000 tons of American scrap. One-tenth of the total consumption was American scrap, three-tenths imported iron, and six-tenths American pig. The consumption was divided as follows:—In casting, 1,103,000 tons; in railroad supplies, 2,478,500 tons, and in miscellaneous wrought iron products, 730,000 tons.

The ore production for the past year was very largely in excess of that of previous years, being 6,400,000 tons.

The report further states that five Bessemer works were in operation (four new ones being projected at date of report), consuming 125,361 tons of pig metal, and fixes the production of Bessemer rails for the year at 90,000 tons.

Hoosac Tunnel.—The progress of this work, up to the 1st of March, 1873, is stated to be as follows:

Extension of headings during the month of February, 277 feet.

Total worked accomplished: from the east end, westward, 13,480 feet; from the west end, eastward, 8,966 feet; total, 22,746 feet. Leaving still to be opened, 2,555 feet, or somewhat less than half a mile.

An Improved Safety Lamp.—An invention ascribed to Mr. William Yates, claiming to be a great improvement upon the Davy Safety Lamp, is thus described:* The wire gauze is removed from that part of the lamp surrounding the flame, and its place is supplied with a bull's-eye glass in front and a polished silver surface behind; thus securing a brilliant, cheerful light, and removing the temptation, which with the old lamp is very strong at times, to remove the gauze to obtain sufficient light. The light thus obtained is stated to be twenty times greater than with the old Davy; and again, the flame is placed so low that it cannot be made to approach the gauze by the breath or by tilting the apparatus. The lower portion of the lamp,

* Engineer, Feb., 1873.

containing the oil reservoir and the wick, which is screwed to the part which consists of the gauze funnel, the bull's-eye and the reflector, has a spring-bolt attached to it which catches each time the screw is turned, and finally locks together the two parts of the lamp. The bolt is easily removed by another screw, but this cannot be done without, at the same time, withdrawing the wick and extinguishing the flame, thus making it impossible to obtain a light by opening the lamp.

It seems, therefore, that this new improvement remedies the defects of the old lamp, to which many of the accidents occurring in the mines are attributed.

Silk Manufacture.—The statistics of this industry in the United States indicate a most surprising and gratifying increase. Ten years ago it was in its infancy, and purely an experiment; now it has attained to vast proportions, and bids fair to speedily become one of the most prominent manufactures of the country.

The recently published annual report of the Silk Manufacturer's Association contains the statement that $30,000,000 are invested in this industry in the country, and sixteen thousand operatives are employed, whose wages reach $8,000,000, and the value of whose production is estimated at between 30 and $40,000,000.

A New Solvent for Iodine, BY DR. I. WALZ.—I find that glacial acetic acid is an excellent solvent of iodine, certainly not inferior to alcohol. On heating acetic acid with excess of iodine to boiling, and then allowing to cool slowly, beautiful, large, slender crystals of iodine will form (sometimes half an inch long.) The crystals formed from supersaturated alcohol solution of iodine are short, of arrow-head shape, and by no means so abundant, for glacial acetic acid takes up far more iodine hot than cold. I hope you will make this easily executed experiment, and you will then see the finest iodine crystals yet produced.

If saturated alcoholic and glacial acetic solutions of iodine are mixed in equal proportions, and allowed to stand, *acetic ether* is formed. The presence of a little MnO_2 and a drop of SO_4H_2 seems to promote the formation, but is quite unnecessary.

Elongation by Magnetization.—Prof. Mayer has announced some instructive conclusions from a series of experiments upon magnetism. These experiments were made with a view to determine any change of dimensions suffered by bars of steel or iron by magnetiza-

tion. The apparatus employed for this purpose was extremely delicate, and capable of measuring a variation in length of one two hundred thousandths of an inch. By means of this apparatus he determined that bars of iron suffered an elongation when a current of electricity was passed through them; when the current was interrupted the bars shortened somewhat, but never quite regained their original length. With annealed steel bars the results were the same; but with tempered steel they were quite different. Upon passing a current around these they contracted, and on interrupting the current they contracted still further.

A New Colorimeter.—A new instrument of this kind has been suggested. It consists of two pieces of glass, touching at one end, and held apart at the other by a strip of platinum.

Upon one of the plates a series of fine lines is engraved; and the intensity of any two colors is determined by comparison of the depth of liquid which it is necessary to add until the lines before referred to become invisible.

The Oxyhydrogen Light.—The conclusions reached by M. Le Blanc, who has given the new method of illumination a thorough examination, are that in point of economy it affords but little gain over the ordinary method of gas lighting.

The method of illumination cannot well be carried into effect without the attachment of carburizers and regulators at the foot of each lamp-post. The friends of the invention in France are said to acknowledge that the plan is not practically adapted for street illumination.

Correction.—In the March number of the Journal, in the description of an improved testing machine, on page 146, there occurs the statement that, owing to a peculiar arrangement of the bearings and fulcrums of the machine there was *no* friction. The error was, at the time of printing, overlooked, in making a hasty abstract of a lengthy description which had been offered for publication. As the statement, if uncorrected, might lead to the suspicion that the Editor was a convert to the doctrine of perpetual motion, this opportunity is taken to call attention to the misstatement.

Obituary.—There was none greater, in the science of engineering, in the broadest sense, than William John Macquorn Rankine, late Professor at the Glasgow University, recently deceased in that

city; and the following resolutions, passed at a meeting of the Faculty of the Stevens Institute, testify to the esteem, we might almost say veneration, in which Professor Rankine was held by his scientific *confreres* throughout the world.

At a special meeting of the Faculty of the Stevens Institute of Technology, held Wednesday, January 15, 1873, the following resolutions were moved by Prof. Thurston and unanimously adopted:

Resolved, That we have learned with profound regret the death of Professor William John Macquorn Rankine, of the University of Glasgow, Scotland.

Resolved, That in his death we feel that we have lost a most eminent member of the Engineering Profession, a distinguished brother in science, a rarely-gifted scholar, and one who, in a degree seldom equalled, has aided the great cause of the application, in technical and general education, of scientific knowledge.

Resolved, That we find, in the vast amount of valuable work accomplished by the deceased, causo of thankfulness to Him who doeth all things well for the preservation until now of so fruitful a life.

Resolved, That copies of these resolutions be forwarded through the United States Consul at Glasgow, to the Council of the University of Glasgow, and to the family of the deceased.

HENRY MORTON, President.

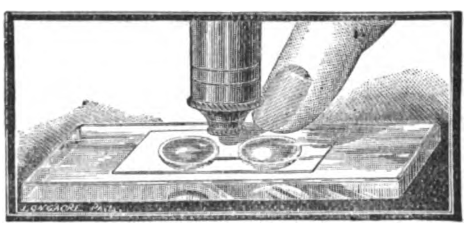
C. F. Kroeh, Secretary.

OPTICAL SECTION.

A New Slide for the Microscope.—At a recent meeting of the Optical section there was described and exhibited in operation a new adjunct to the microscope, designed by Mr. D. S. Holman, a member of the Section, whose life slide recently attracted so much attention and comment.

The new device may be called a current cell, and is designed to afford the microscopist the opportunity of observing and studying the constitution of the blood and other organic fluids with much greater ease and precision than it has heretofore been found possible to attain.

The accompanying illustration will serve to make the description of its construction and operation manifest:



The slide consists of a plain piece of plate glass of considerable thickness, and three inches or more in dimensions. This is furnished at equal distances from its centre with two well

polished shallow cavities of circular form, which are connected with each other by two capillary channels. These channels are likewise polished, and to permit of a greater field in focussing for their contents, the groove of the tube is made triangular in section, with one side forming a right angle with the surface of the slide, and the other forming with it a very large angle.

The arrangement of the cell, or moist chamber, is as follows :

In order that the current shall be most sensitive, the slide should first be brought nearly to the temperature of the body by holding it for a few minutes in the hand. A small quantity of the liquid to be examined (blood, for example), is then to be placed in each cell, and a thin cover glass placed upon them. If held down for a moment with the hands, the air within the cavities will become slightly rarified, and the cover glass so firmly held in place by atmospheric pressure as to require no artificial attachment.

Upon removal of the fingers, it will be found that the centre of the cavities is occupied with a bubble of air, while a thin annulus about the circumference, as well as the connecting capillary tubes, are occupied by the fluid.

The slide is now ready for inspection. If placed beneath the microscope, and the instrument is focussed upon the connecting channel, a number of corpuscles, red and white, will be observed, but quite quiescent. Let the finger be now approached to the neighborhood of either cell, when at once a current, more or less rapid, according to its proximity, commences to flow beneath the object glass; remove the finger, and the direction of the current is reversed.

The current is caused by the expansion of the air bubble in the cell, in consequence of the heat radiated from the finger; and its rapidity may be controlled to a nicety by regulating the proximity of the finger. So sensitive is the apparatus, that even with the highest powers, a corpuscle, granule or cell in the field of view, may be leisurely turned over and over in any desirable position, thus affording an unequalled means of observation and study to the microscopist; and while the eye is examining at leisure the behavior of the objects beneath it, the mind is charmed with the simplicity of the means by which these motions are controlled.

In the cell here described, no foreign liquid is added to the material under examination.

Moreover, if each cell be entirely filled, but with liquids of different densities, the cell holding the denser liquid being placed slightly

uppermost upon the rotating stage of the microscope, the action of gravity will cause two currents to flow in opposite directions through the communicating channels, and in this way the phenomena of transfusion, crystallization, etc., may be observed for a considerable length of time, which otherwise are brought to sight only with difficuly.

At the conclusion of the description, the ingenious and useful device was highly praised by those members present, who were best able to appreciate its value, and its exhibition beneath the microscope was the occasion of much interest.

Bibliographical Notices.

On the Strength of Bridges and Roofs. By SAMUEL H. SHREVE, C. E. New York: D. Van Nostrand, 1873.

There has probably been no one branch of technical engineering literature upon which so many pamphlets, essays and treatises have been written, as upon the subject of bridge and roof construction; and it might be made an interesting subject of speculation to inquire the reason for such an expenditure of mental force in that direction. To add to the theoretical division of the subject, little or no room is left for the original investigator, always excepting the discussion of swing bridges and the rigid and braced arch, concerning which we have little that the practising engineer can readily understand or apply. We may divide the various modes of treating the subject most conveniently into the "Arithmetical," the "Analytical," and the "Algebraic," which, while strictly an incorrect division (as any treatment must be analytical), still it answers the purpose for the present, if we understand the intermediate method as the one employing the calculus and "higher" mathematics.

To the last class Mr. Shreve's book belongs, and throughout he has kept up a harmony of discussion and symbols that is in strong contrast with the mixed methods employed by most writers on such topics. While, of course, there is nothing new in the abstract in any of Mr. Shreve's discussions, there is a great deal in the mode of applying well recognized principles, as well as in the natural progression from simple to complicated forms of trussing. He has adopted the method of sections, a process of great flexibility, but as developed by all other authors, it involves an amount of time for its application not usually at the disposal of the engineer. The method of sections requires no "refined" mathematical knowledge, but it does require familiarity

with the simpler algebraic processes, as well as a knowledge of the elementary laws of mechanics as embodied in the principle of the lever and the resolution of forces. It has a further value in that it is perfectly general for all trusses of whatsoever form, such forms being always special cases under the general law. For this reason, it is probably the *best* method of bringing before the student a comprehensive theoretical knowledge of bridge construction, which, of course, must be mastered before he can make a further step forward, and learn to put his "strain diagrams" into a practical shape. For office practice, no method can ever supersede the arithmetical method, as first suggested by Mr. Whipple twenty-six years ago—that is for *parallel beam trusses*, a method of analysis now used by nearly all actively employed engineers, perhaps with some modification, but essentially the same now as then.

It is useless to expect other than "student engineers" to revel in the calculus and such analytical methods, and it is that which has marred more than one of our intended text books. Mr. Trautwine, in the preface to his "Hand Book," expressed a sweeping contempt for "mathematical rubbish," and as he probably meant it, he was quite correct. "Linea brevissima recta est" must be, of necessity, the engineer's motto, life being too short for "elegant refinements" after a man has passed his college days; only he must be careful to be sure that his straight line is in the right direction, or he may find himself sadly astray. There are some higher forms of trussing, in which it is difficult to avoid algebraic analysis of some sort, forms which arithmetical methods fail to reach—such as bow-string girders, lenticular and curved chords. The resolution and composition of forces so often applied to such forms are fearfully tedious, not to mention the errors multiplying through so much scale transferring. It is just here that we must beg aid from the "mathematical rubbish," and there probably can be nothing simpler than the method of sections applied to such forms. It will always meet the case, and, as Mr. Shreve has shown us, in a way that appears to be the essence of simplicity. Under a variable load, the difficulties by any other method intensifies to a brain-splitting degree, and while it is bad enough even by the method of sections, it is probably the only one that can be employed successfully by the average educated engineer. All writers, so far as the writer is aware, flounder on the bow-string variably loaded, if they avoid the method of sections. Who could rise from a perusal of Rankine, and say that he understood his discussion of it?

Mr. Trautwine does not touch it, but simply quotes Rankine, frankly disavowing any knowledge of what Rankine meant. Stoney, whose work, taken all in all, is the best treatise in the language on the subject on which it treats, and which no constructing engineer can afford to be without, descends from his usually simple manner of discussion, and gives a special case, worked out by the never ending and error-multiplying resolutions of forces. Humber deals in glittering generalities, and leaves the enquiring student profoundly impressed with the higher mysteries of the profession. Ritter's "Bridge and Roof Construction" (most *wretchedly* translated, scissored and printed by Diedrich in his(?) "Theory of Strains"), is in the main an arithmetical application of the method of sections, covering all possible forms of trusses, arches, domes, etc., and with a degree of thoroughness that only a German has patience to develop; but, being *arithmetical*, the processes are long and tedious, besides which the manner of taking moments allows of error. For a bow-string, for example, he passes a plane through each panel, so as to cut but three members, the intersection of any two prolonged being used for the centre of moments for the web members, the centres of moments in the web chords being, of course, taken in the chords themselves.

Coming, now, to Mr. Shreve's book, we find the radical modification of the usual manner of treating the method of sections consists in his deriving the web strains from the horizontal components of the chords, and by so doing he has been enabled to so simplify his formula as to make them readily available. It is the web strains that have always given the trouble, the chord strains being readily enough computed.

The arrangement of the book is admirable, the student being led gradually from the simpler to the more complex forms, the same formula following him throughout, simply being modified as the several cases vary. No case is treated as a distinct topic, isolated in itself, but merely part of the whole, in which its great value to the student in a great measure consists. *Every* form of truss treated is followed by an example worked out in detail, showing the application of the formula an excellent aid to a proper appreciation of the method of investigation. There are a few engineers still living who adhere to the idea that the centre brace is unaffected by the dead load of a structure, and therefore is required to be of full section, and extended throughout the whole length of the truss. To such the discussion of Mr. Shreve on the subject will be of value as being clear and con-

vincing, in which nothing is *assumed*, but deduced purely from the few simple mechanical axioms that lie at the bottom of all construction. This is a noteworthy peculiarity pervading the whole book, and not the least among its merits. Mr. Shreve has been happy in his explanatory remarks, indulging in no verbosity, but expressing tersely and unmistakably just what he means, leaving nothing to be inferred. In a little over 300 pages he explains and analyzes under one system almost all forms of independent trusses, giving worked-out examples of each, and in many cases takes his examples from actual structures.

Some ten pages are devoted at the end of the book to the subject of columns, which not being subject to theoretical analysis, is evidently out of place in a book of this character. Besides this, the information given is meagre, and amounts simply to quoting Hodgkinson's formulæ for cast and wrought iron columns, not touching Gordon's rule at all—the rule by which most engineers are governed, as being convenient to apply and perfectly safe.

The rules for the strength of columns are purely empirical, and therefore their discussion belongs more properly to the "strength of materials," which Mr. Shreve does not touch at all.

Apart from this unwise addition to the book, Mr. Shreve has produced a work that must always take high rank as a text book, and while not exactly fulfilling the requirements of an office hand-book, no bridge engineer should be without it as a valuable work of reference and one that will very frequently assist him out of difficulties.

As before remarked, for trusses with curved chords, bowstrings, etc., it appears to be clearer than any book heretofore issued, so far as examined by the writer, and it is hard to imagine anything more simple than the manner in which Mr. Shreve adapts the "Method of Sections" to such forms. The author promises a second volume, extending the same principle and methods to the consideration of continuous girders, swing bridges, cantilever trusses, braced arches, etc., and it is to be hoped that the profession will not be kept long waiting for it. The publisher deserves a good word for the handsome manner in which the work is produced, in the well arranged type, thick toned paper and substantial binding, although a little more care in the press work would still further have enhanced its appearance.

ALFRED P. BOLLER.

New York, March 7th, 1873.

Civil and Mechanical Engineering.

BESSEMER MACHINERY.

A Lecture delivered before the Students of the Stevens Institute of Technology by ALEX. L. HOLLEY, C. E.

(Continued from Vol. LXIV, page 399.)

The Bessemer blowing cylinder valve, at first universally and still somewhat used, is shown by Fig. 10. It is simply a rubber band, encircling the end of the cylinder, and opening and closing the air-holes, over which it lies, by automatically stretching and contracting.

Fig. 10.

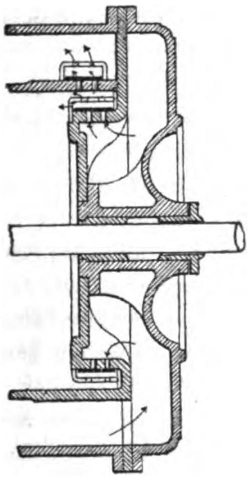
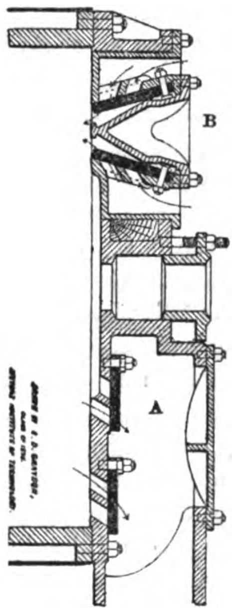


Fig. 11.



These valves rapidly fail from the heat and stretching, even when the cylinder is cooled by water-jacketing, and they are somewhat inaccessible for repairs.

A modification of the blast-furnace flap-valve is more generally approved. Fig. 11 shows it as applied to a vertical Bessemer engine at the Cambria works. A are the ejection-valves. The induction-valves, B, have the smallest possible clearance and consequent waste of air.

The positive-valve motion—large piston-valves opened and closed by the engine—is being substituted abroad for automatic valves. This is an improvement, compared with the early Bessemer valve, Fig. 10, but it is costly, and it has its own peculiar difficulties. A good rubber valve (Fig. 11), ⅝ inch thick, and resting on a grating with one-inch openings, is quite satisfactory, provided the access for repairs is good and the cylinder and head are water-jacketed.

There is a constant impression in the minds of capitalists, and even of general engineers, that any given iron- and steel-making machinery may be cheapened—that less heavy and less accurately fitted parts will do—that all this duplication is not absolutely essential—that masonry buildings, and iron roofs especially, are mere luxuries, and that it is better to make a little less product, and to take the risks of breakage and fire, rather than to pile a million dollars, before earning the first cent, into what may be called a complete steel rail plant, viz., four vessels and appurtenances, a blooming-mill, a rail-mill, a small merchant-train, and the necessary furnaces, fixtures and movables.

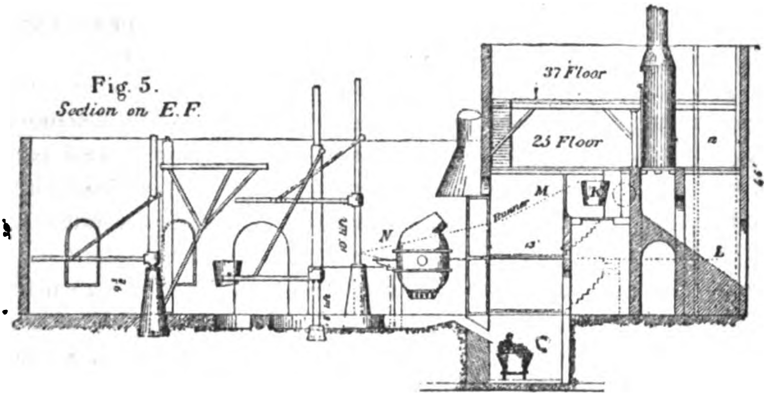
These impressions, however, are contradicted every day by the current history of the iron business. Competition springs up in more favorable mineral localities—what do the old works do? Tear out their old machinery and build better—and so, by producing more cheaply, keep in the field. The whole matter lies in a nut-shell. Works that will stand *hard crowding*, day and night—works where steam-machines can *get enough to do* to make it worth while to substitute them for muscle—such works cost less to construct, and to run, *per ton of product*, just in proportion to their bigness, always provided they do not grow out of reach of a reasonably compact, homogeneous and well-organized management.

We come, finally, to the *general arrangement* of fixtures and machinery. The standard English plant, as worked out by Bessemer and still adhered to in England and on the Continent, excepting only in a very few of the later works, is shown in Plate V, by the side of the standard American plant now adopted, with a few changes in detail, in all American works. The American plant is farther illustrated by Fig. 12. This new arrangement is found necessary to a large and economical production.

Its most conspicuous feature is the arrangement of the vessels, especially their height above the general floor, and the consequent shallowness of the casting-pit. The English vessel centres stand only three or four feet above the general floor, and the bottom of the cast-

ing-pit must hence be eight or nine feet below it. In this confined, unventilated and comparatively inaccessible gulf the largest and the hottest manual work is performed. Here the steel is poured and the

Fig. 12.



red-hot ingots and moulds are handled. In the American plant, the vessel centres are nine feet above the general floor, and the pit is but 30 inches deep—just deep enough for convenient casting. All the operations of casting are performed, all the ingots and moulds are handled, by men standing on the general working floor of the building. Convenient access, free ventilation, and a short lift of moulds and ingots are thus secured. The high vessel also allows the removal of the vessel bottoms on the general floor; and there is a second story of working room, by means of the platforms around the vessels, at the level of their centres. The runners are accessible for repairs, and the vessel noses for the insertion of scrap, from this platform. When highly siliconized or hot irons are used, some steel scrap is put into the vessel cold, and melted as well as reconverted with the iron charge.

Placing the vessels side by side is not new. Bessemer did it in his early practice, but not in such a way as to realize the advantages we are considering. In the American plant the rear of the vessels is open to a floor in the cupola building from which they may be conveniently fired, and where the tuyere-boxes may be opened, the tuyeres repaired, and the vessel bottoms set. The converting-house floor under the cranes is thus clear for ladle repairs—12 to 15 casting ladles are required,—for storing ingot-moulds, and for other purposes requiring crane power. The vessel chimneys, standing in the

wall of the building, occupy no useful space; whereas in the English plant the vessel repairs and the vessel chimneys take up valuable room under the cranes, and the chimneys prevent the cranes from revolving through an entire circle.

In the American plant the diameter of the pit is also increased, to allow several sets of ingot-moulds to be put in at once, and the available pit room is also enlarged by placing the vessels at one side of it, rather than on opposite sides.

Instead of two ingot cranes three are placed over the pit, two of which command the vessels. For handling a hundred tons of ingots, and double this weight of moulds, twice over every day, besides the mould bottoms and ladles, this additional crane capacity is indispensable.

The vessel bottoms are removed and replaced by means of a hydraulic lift and a car under each vessel. The exterior trunnion of the vessel is supported by a beam instead of a pier, so that the vessel bottom or a whole section of the vessel can be removed laterally for repairs, after it has been let down upon the car by the lift. Both inner trunnions are supported on an iron or masonry pier. In some of the American works the hydraulic cylinder for rotating the vessel is arranged vertically, below the floor, as shown in Plate V, fig. 9, to save room as compared with the horizontal English cylinder.

In several American works now constructing, the vessel cylinder, Fig. 18, is placed above the trunnions, for convenience of repairs, and to allow a longer stroke and hence greater steadiness in the movement of the vessel.

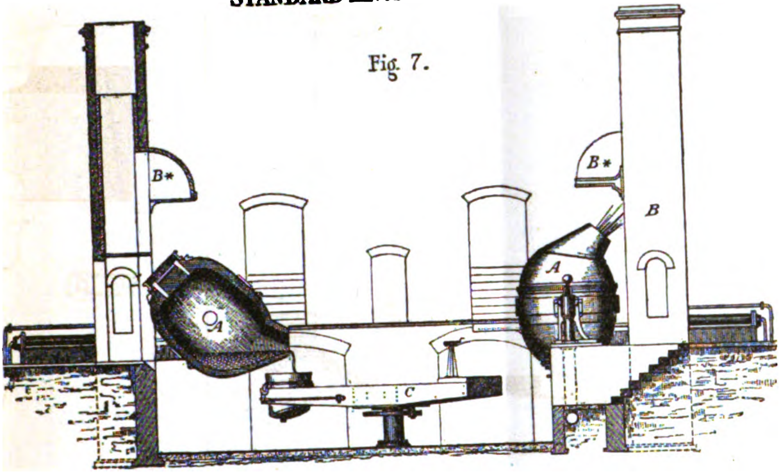
A front elevation of converters, thus arranged in the North Chicago Rolling Mill Company's works—the latest and most improved Bessemer plant started in America—is shown upon plate.

The plates show in detail the particulars and latest proportions of vessels and associated members. The upper and lower parts of the vessels are sections of cones instead of spheres, to save cost in construction. The cars under the vessels are moved by hydraulic cylinders.

When the steel is intended for rails—and 90 per cent. of that made in this country is so used—the charges are so regulated as to cast either eight or ten ingots, and a little over, as a margin for chilling and spilling. Each ingot makes two rails; it is usually 12 or 13 inches square at the bottom, tapering to 11 or 12 inches at the top—so as to slip out of the cast-iron ingot-mould,—and 3½ to 4½ feet long, weighing 1300 to 1600 lbs.

STANDARD ENGLISH PLANT.

Fig. 7.



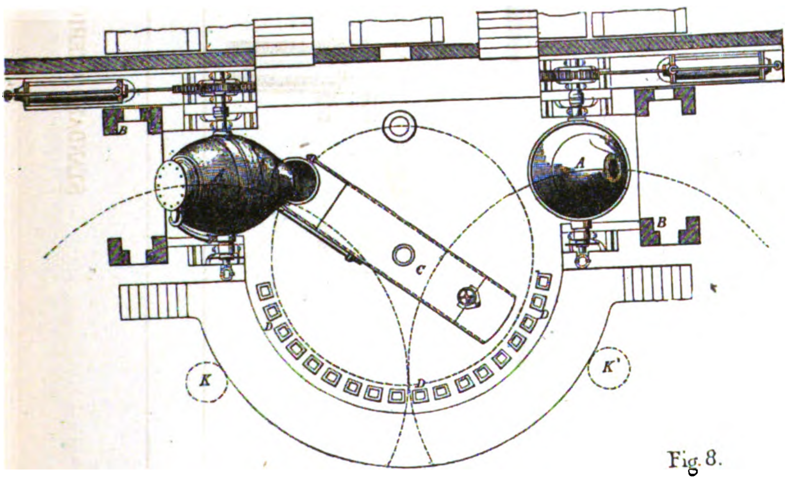


Fig. 8.

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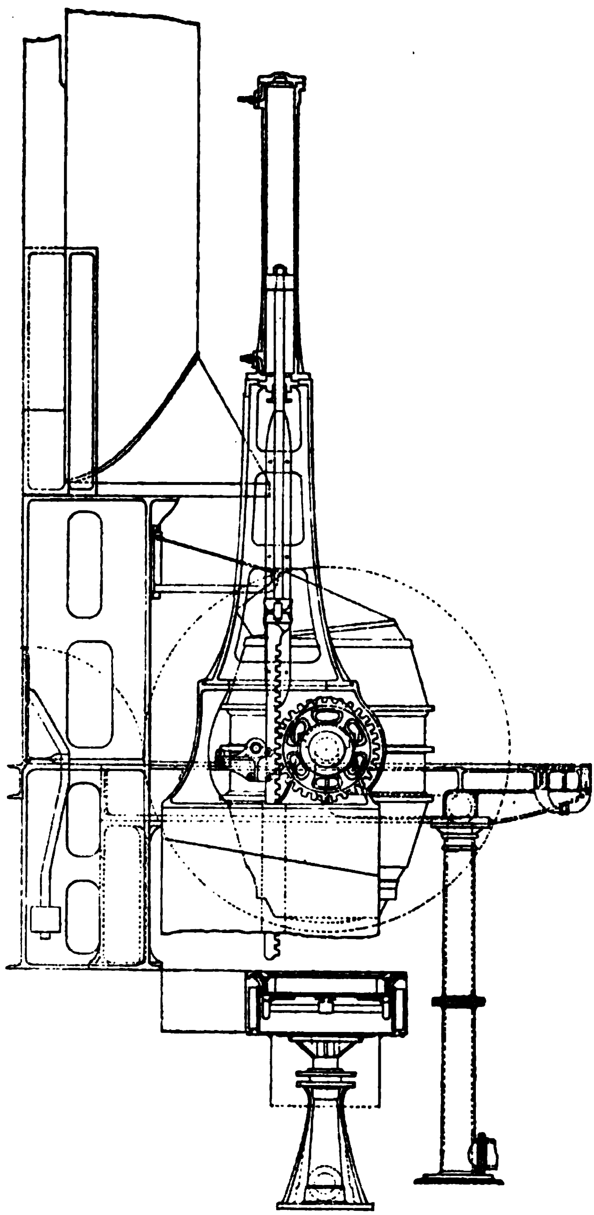
The ingots are removed hot, each charge together on a car, to the blooming mill, and if any heating furnace is ready, they are charged

Fig. 13.



into it directly, thus saving much heat. They must be allowed to crystallize, however, before rolling. If the interior of an ingot is still pasty from the heat of conversion it will go to pieces in the rolls.

Double ingots are used instead of ingots for single rails, 1st, to save a repetition of manipulations in working. This must be done by machinery to be done cheaply, and a *machine* can handle a big ingot as quickly as a little one. 2d. The extreme top of an ingot is unsound, and must be cut off and reconverted; a double ingot yields but one scrap end for two rails. 3d. A single rail might be rolled from a 7 in. or 8 in. ingot, but the steel would be too little condensed; a 12 inch ingot receives three times as much work in the rolls, and the density and uniformity of the bar are improved in proportion. The practice is growing in the direction of large ingots and large reductions for all purposes; and the counterpart to this—to cheapen cost—is handling by steam, and reducing rapidly by heavier rolls and hammers.

At the Bethlehem steel works, now constructing, 16-inch ingots for four rails each, are to be rolled, at one heat and two re-heats, into rails 60 feet long, these being afterwards sawn to the standard length of 30 feet. Steam-handling, both at the ingot-rolls and the rail-rolls, will pay the cost of this extra heating, and the quality of the product will be improved.

Ingot-moulds are cast from open gray iron, and when their interior surfaces are properly protected from the immediate contact of the steel by a wash of clay or plumbago, they endure 50 to 100 heats. A large body of melted cast-iron, poured into a cast-iron ingot-mould, will adhere to its sides. An equal mass of fluid steel, though of twice the temperature, will not so adhere. The reason is that the steel instantly chills and contracts away from the mould, while the more slowly chilling iron remains in contact until it has partially fused and united with the surface of the mould.

Casting ingots in groups—that is to say—pouring the steel into a central sprue, and allowing it to enter the bottom of a number of moulds at a time, through a fire clay distributor, has been the subject of much experimenting, and many improvements, in this country. The stream of steel, instead of falling from the top to the bottom of the mould, and spattering against its sides, thus causing a cellular texture and incipient cracks, rises slowly and quietly from the bottom. The ingots are more smooth and sound, and the endurance of the

moulds is doubled. For small ingots, this system is indispensable; for large ingots, it is still on trial; but it is probable that the cost of moulding the distributing bottom will be more than compensated by the saving of unsound product. The best average practice in this country, with standard irons, does not yield above 2 per cent. of second quality rails.

By referring again to Plate I, we may observe some other features of the latest practice, the object of which is to economise labor and facilitate the handling of a larger product.

The two cupola hoists, a and b, fig. 2, one for coal and refractory materials, and the other for iron, are placed at the two corners of the building, in order to secure more working and storing room in the charging yard than when the hoists are side by side. The ground on three sides of the cupola building is thus utilized. All the varieties of iron of which a charge is composed, are mixed by weight, in charging wagons, by means of a charging scale with several independent beams. The wagon is run upon the scale; No. 1 iron is thrown in till No. 1 beam rises; No. 2 iron is then added till No. 2 beam rises, and so on till six or seven are mixed, without loss of time or risk of arithmetical mistakes. Hand wagons, holding one ton each, are preferred to railway cars of larger capacity, because the former are readily hauled by one man, and not being confined to a track with its switches and comparatively short curves, can be more conveniently manœuvred. The iron and coal are charged directly from their wagons to the cupolas—not dumped on the floor, as in common foundry practice.

When the cupola bottom is opened, after the day's work, the mass of slag and debris that had accumulated in it, slides down the incline below, and spreads out in a thin layer on the ground, where it is easily cooled and broken up. It is then carried to the cinder-mill, or tumbling-box, *c*, conveniently near, where the cinder is broken up and escapes in dust; the shot iron remaining is dumped into a wagon, ascends the adjacent iron hoist, and is again charged into the cupola.

A fifty horse engine for the fan-blowers, cinder-mills, and stone-grinding machinery, occupies the remaining ground floor at this end of the building. The opposite end is used for grinding and preparing ganister, clay and refractory mixtures.

Much ground room and some cost of construction are saved by placing the cupolas at such a height, that the metal charged into them will flow to the vessels by gravity, as compared with the plan of setting the cupolas on the ground, and raising the metal after melting.

The space under the cupolas and ladles is conveniently employed as storing-bins for tuyeres, stoppers, and such fuel and refractory materials as are used about the works in small quantities. The cupola building being higher than the surrounding buildings, its four sides are open for ventilation.

The cupolas stand directly on the 25 feet floor, instead of being raised on legs as in foundries. This avoids the necessity of separate platforms for tapping and for clearing out the tuyeres; and it entirely shuts off the heat, dust, and steam of the debris from the working parts of the building when the cupola bottom is dropped.

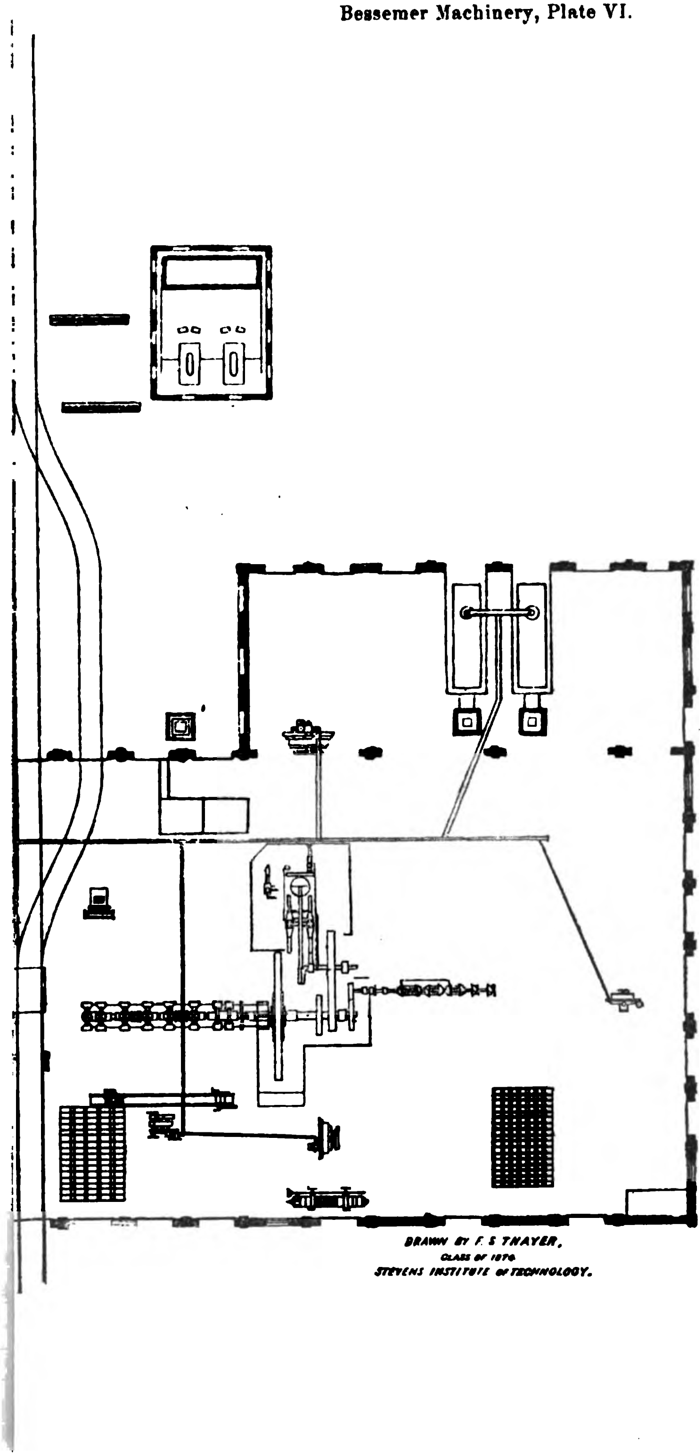
The slag from the vessels and casting ladles—some 20 tons per day—is dumped in the pit and quenched by a jet of water. Then, instead of being shovelled up to the general level—nine feet or more in the English works—and here shovelled again into barrows and wheeled away—it is, in the works here shown, thrown through openings behind the vessels down into a dumping-car, which, when filled, is run upon the coal hoist, lifted to general level, and drawn—by steam if preferred—to the dumping ground. The air and water pipes from the regulator to the vessels and cranes, also lie in this subterranean passage, where they are protected from frost, and accessible for repairs. Burying hydraulic pipes has been a costly experience in this country.

The floor, A, B, fig. 2, behind the vessels, on the general level, is made a thoroughfare for wagons or a railway, as convenience may require. The ends of the converting building are left open to the yard, so that a railway may run straight through, across the pit and under all the cranes.

Ovens for drying vessel bottoms, ladle stoppers and clay and brick-moulds, when these are employed, are so arranged as to be commanded by the two side cranes.

Many minor refinements of arrangement and construction have been instituted in American works, and as the engineers of our great iron establishments are taking up the steel manufacture, we may confidently look for still other changes and economies in detail. It is probable, however, that the fundamental mechanical features so boldly and successfully brought forward by Mr. Bessemer, will always remain prominent.

I regret that our limited time has required such a hasty and perhaps inadequate consideration of the Bessemer manufacture, and the omission of many interesting features altogether.



DRAWN BY F. S. THAYER,
CLASS OF 1876
STEVENS INSTITUTE OF TECHNOLOGY.

Our chief object will have been accomplished, however, if the somewhat remarkable adaptation of this machinery to the work required shall have been made manifest, and more especially, if these considerations shall confirm to students in mechanical engineering the useful lesson that, while practice and precedent should never be ignored, there *are* occasions for radical innovations and new departures.

TESTS OF THE WORTHINGTON PUMPING ENGINE.

By William M. Henderson, Hydraulic Engineer.

The majority and minority reports upon the tests of the Worthington Pumping Engines at the Belmont Water Works, of this city, which took place nearly a year ago, having been laid side by side before the readers of the Journal, affords an excellent opportunity for comparison. I would propose an additional test, to ascertain which of these two reports is to be depended upon. The report of the experts and engineers appointed by the Councils of Philadelphia states that the engines performed a duty of 54,416,694, being 8·83 per cent. in excess of the guaranty; and these gentlemen have shown, by elaborate calculations, how that duty has been ascertained. The report of the expert and engineer, selected by the Citizen's Committee of Thirty, states that the engines, even under such favorable circumstances as surrounded this special test, only performed a duty of 44,679,000, or about 12 per cent. *less* than the duty guaranteed, and about 22 per cent. less than the finding of the experts appointed by Councils, and this gentleman has also given the figures used in the calculation to show how such duty has been ascertained.

Now they cannot both be right, and, as this is a matter that has occurred in the same city where the Franklin Institute Journal is published, which contains the said reports, and which Journal is received as the acknowledged exponent of American applied science, both at home and abroad, we are directly interested in the settlement of this doubtful question; the problem is exclusively our own, and we have engineers who can unravel it. The method pursued for determining what shall constitute the elements comprising the peculiar duty of these particular pumps has been enshrouded with unusual mystery, all of which will be enlarged upon hereafter.

Happily there is nothing mysterious about the term "duty" of a pumping engine. On the contrary, it is thoroughly understood by engineers all over the world. There is no special American "duty"

as different from English or Continental duty, and the method for ascertaining the duty of a pumping engine has become a universal standard. Of course, it must be so, or how could the performance of one engine be compared with another, if each party established a method of its own? The measure of coal, as one feature of comparison, has not always been the same. In the early Cornish examples the standard has been taken as a bushel of 94 pounds, while the later English examples base their calculations upon a hundred weight of 112 pounds, while in this country the general practice is to use the Conventional weight of 100 pounds. The comparison by foot-pounds will, however, always remain the same, and, knowing the measure of coals used, the comparison of duty between any two engines, no matter where erected, can be readily determined.

But to relieve us from any doubt as to what is meant by the term "duty" in regard to its application to these particular Belmont pumps, we have but to refer to an official letter, dated May 26th, 1868, written by the late Chief Engineer of our Water Department to Councils, upon the fulfilment of which was based the awarding of the contract for the engines here referred to. I quote from the letter as follows:

"I give below a tabulated statement of the duties of a number of engines *taken in all cases from annual reports* and other printed documents; *when the word duty is used, it refers to the number of pounds of water raised one foot high by the consumption of one pound of coal,* technically called 'feet-pounds;' the duty therefore will show the comparative economy of fuel consumed by each engine named.

"The *annual report* of the Charlestown Water Board for the past year gives the average duty of the Worthington Duplex Engines for the *whole year* as 679,690 feet-pounds. The average *annual duty* of our Twenty-fourth Ward direct acting Cornish engines was 530,400 feet-pounds. By this it will be seen that the duty of the Worthington Engines was 22 per cent. more than the annual average of the Twenty-fourth Ward Cornish, showing that there would have been a saving last year, had we used engines similar to those at Charlestown, of $2,644·76." (Vide Journal of Select Council, 1868, Appendix, 174, pp. 1239 to 1243).

The bid of the New York firm was $95,000, and that of the Messrs. Merrick $57,000 for the same work. Notwithstanding this very considerable disparity in cost, it was thought best by Councils, upon the recommendation of the Chief Engineer, and with the distinct understanding that the Worthington engine should perform an annual duty

of at least 679,690 foot-pounds, or 67,969,000 pounds of water raised 1 foot high by each 100 pounds of coal consumed, to award the contract to the builder of these engines.

Such being the inducements presented to Councils which influenced the awarding of this contract, it is a very simple matter to ascertain whether the promises then made have been fulfilled. Strictly speaking, the result of the test lately made does not enter into the question at all, being merely experimental, and conducted for a brief period only, to ascertain what the engines could be made to do under the most favorable circumstances, and which could not have been maintained in practice. As a ruling out of this manner of testing, we are expressly informed that the promised duty of 679,690 foot-pounds is to be derived from the results obtained during each *annual* run.

Taking, then, the *annual report* of the Chief Engineer of the Water Department, presented to Councils February 8th, 1872, being the first one containing the history of the working of the engines under discussion, we find upon page 20 the following data, which enables us to arrive at the annual duty for 1871.

$$\text{Duty} = \frac{\overset{\text{Total gallons pumped during the year.}}{1{,}054{,}210{,}990} \times \overset{\text{Weight of 1 gallon.}}{8\cdot 34} \times \overset{\text{Height in feet.}}{208} \times 100}{\text{Total coal consumed, } 4{,}816{,}309} = 37{,}970{,}173,$$

or about 79 *per cent. below the standard.*

For the single month of January of last year, the duty was 37,884,-657. The average duty of April last year was 39,232,500.

The annual duty for the past year (1872), was 39,619,801 (see page 40 of the Annual Report of the Chief Engineer of the Water Department, presented to Councils January 30th, 1873), and from the figures given to and published in the daily papers of this city, we find the duty for the month of January of the current year to be 38,167,-700, so that now the duty of these engines is pretty well established; with these figures before us, it would seem that the annual duty of 67,969,000, the only matter of interest to our citizens, has not nor cannot be obtained.

Now, admitting the duty given by the majority report of the Committee which conducted the late experimental test, viz., 54,416,694, we have still a deficit of 13,552,306 pounds of water *not lifted*, or about 25 per cent.

The notable objections urged to the manner pursued by the experts and engineers appointed by Councils to test the Belmont engines, are as follows:

1st. The manner in which the coal was selected, screened, picked and stored exclusively for the test, instead of pursuing the course of daily practice, is pointed out without comment.

2d. The manner pursued in charging the furnaces with heavy, clean fires before the test began, sufficient in themselves to run the engines for a considerable time without addition, of which no account was taken—the usual practice being to run the fires down as low as possible, without actually stopping the engines, at the commencement of the test, and running the engines at the close of the test until they arrive at the same condition, and then stopping them.

3d. The manner of running the fires down at the close of the experiment, and leaving them in an impoverished condition.

4th. Allowing the engines credit for 9·5· lbs. of water evaporated per lb. of coal consumed, when the evaporation was only 7·5 lbs. This excessive evaporation allowed being rarely attainable in practice, the usual course pursued in such cases furnishing no precedent, the result is of no practical value, being purely hypothetical.

5th. Calling one-third of the ashes *coals* (1450 lbs.), and crediting the engines with that amount. Objected to because coals so small as to pass through the bars must, from that fact, be classed with the refuse. If there was this large amount of coal actually there, what prevented it from being turned to account?

6th. Forcing the engines continuously beyond their safe working stroke to within the dangerous proximity of five-sixteenths of an inch of the cylinder heads, as this could not be maintained except (as was the case here) by the superhuman exertions of two attendants sent by the builder of the engines to manipulate them.

7th. Irregularities detected by several witnesses in the manipulation of the feed-pump which supplied the boilers with water, allowing it to run slowly, feeding water to the boilers of which no account was taken, thus taxing the evaporative power of the boilers without giving due credit.

8th. Error detected by the citizens' expert in the measurement of the water delivered over the weir.

9th. Basing the calculation of capacity of the pumps *independently of the actual delivery of water into the reservoir*, which is about equal to enacting the tragedy of King Richard the Third with the character of King Richard omitted.

10th. Calling the height of the force main 217·74 feet instead of 208 feet, which it actually is. This, in effect, is giving the pumps

credit for mal-construction and insufficiency of water-ways; for it is clear that, if the friction entailed by the passage of water through a pump is to become an element of its duty, then the worst made pump —that in which the passages are distorted, and the water-ways throttled—will perform more duty (labor harder) than a properly constructed pump, having ample and direct water passages; and as the index of the pressure-gauge vibrated continuously from 5 to 8 lbs. at each stroke in these Belmont pumps, it is rather too much to expect that engineers will sanction that the signal defects of a machine are to be counted as elements of its virtues. This is altogether opposed to Cornish practice, or common-sense.

11th. The manner of running the water down in the steam-boilers to a lower level than it was at the commencement of the experiment is objected to, as this was, to say the least of it, unscientific, and has given rise to unnecessary discrepancies, which practically vitiate the conclusions arrived at in the report of the experts appointed by Councils, who state the deficiency in water level to have amounted to 530 pounds of water. They also state the evaporative power of the boiler to have been 8·19 lbs. of water per pound of coal, and give the amount of coal necessary to raise the temperature of this 530 lbs. of feed-water from 130° to the temperature of steam at 48 pounds pressure at 10 lbs. Now, as this is, to all intents and purposes, the same as that required to evaporate it—and we are told that one pound of coal did evaporate 8·19 pounds of water—this 10 lbs. should have been 64·7 pounds of coal. On the other hand, the minority report gives the deficiency in water as equal to a weight of 2,961 lbs., and required a consumption of 357 pounds of coal to restore. Correcting this allowance and that due to the altered state of the fires at the close of the experiment, together with the fact of increasing the stroke of the engine 2·74 per cent., and granting the whole displacement of the pump-plungers, the duty is reduced from 54,416,694 to 47,365,000, as derived from the following formula:

$$\text{Duty}, \quad \frac{\underset{\text{in pounds.}}{\overset{\text{Displacement}}{679}} \times \underset{\text{strokes.}}{\overset{\text{Number of}}{139{,}604}} \times \underset{\text{feet.}}{\overset{\text{Height in}}{217{\cdot}47}} \times 100}{\text{Total coal consumed, } 43{,}522} = 47{,}365{,}000.$$

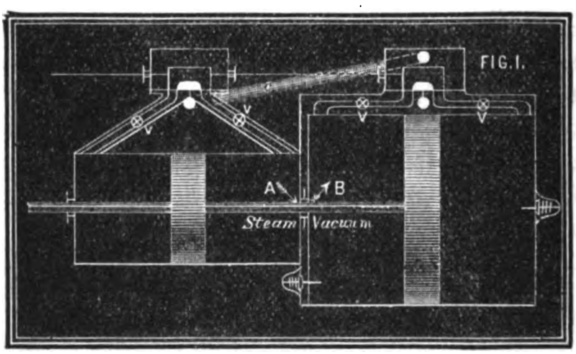
But, as the height was only 208 feet, and as the late Chief Engineer gave us to understand "*when the word 'duty' is used it refers to the number of pounds of water raised one foot high by the consumption*

of one pound of coal," the duty would be, allowing 3·8 per cent. for leakage, 43,591·000.

And this is only an experimental duty, which dwindles into utter insignificance when contrasted with some others obtained from the Cornish engines, to wit:

Fowey Consuls, ...	50 inch,	130,200,000
Holmbush, ...	80 "	122,400,000
United Mines at Guennap, . .	80 "	128,000,000

On the Probabilities of the Case.—The science of engineering being as readily taught to an apt pupil as any other branch of popular education, a person so taught will be able to discover the merits of a machine by an inspection of its design, and will be able to pronounce what general results may be expected from a machine so represented. Such being an established practice, recognized by the readers of the "Journal," who certify their faith in it by subscribing to this periodical, which only conveys to them plans and descriptions of machines they may never have seen and probably beyond the reach of personal inspection, I will avail myself of this current method by producing a cut representing the design of steam cylinders used in the Belmont engines. Each individual reader will then be able to decide for himself what there is in the arrangement that would be likely to produce a duty in the neighborhood of 68 millions of pounds of water raised one foot high by the consumption of one pound of coal, as we were promised, and whether the duty *actually* performed, 39 millions, is not about as much as could reasonably be expected.



A is a high pressure cylinder, or measure of expansion for B, which is the low-pressure cylinder. Double steam ports are provided at the

ends of each cylinder, the outer ports being in all cases the ingress, and the inner ports the egress, with regulating valves, V, between the two, as shown. A stuffing-box has also to be maintained in the head dividing the two cylinders, for the piston-rod to slide through, and a transfer-pipe, C, proceeds from the exhaust port of cylinder A, to the steam chest of cylinder B, for transferring the steam to be expanded from the one cylinder to the other, *the ratio of expansion being limited to three times.*

The manner of cushioning the engines at the ends of the stroke is effected by the pistons travelling over the exit ports some distance before the completion of the stroke, and entrapping a portion of the steam to cushion upon, which is gradually permitted to escape by the outer ports (never covered by the pistons) to the exit ports again, by adjusting the regulating cushion-valves, V, placed between the two for this purpose. In addition to these, other valves are inserted in each head of the low-pressure cylinders, the stems of which project inwards; they are kept to their seats by springs. Live steam from the boiler is supplied to the back of them. Now, in case the cushion valves just described do not act properly, the piston, in going to the limit of its stroke, will strike these open and admit a rush of steam upon the surface of the low-pressure piston, which of course will effectually stop it. It will be observed there are six cushion-valves to each engine, and twelve to the pair, besides which there are employed three throttle valves, introduced in the transfer and exhaust pipes.

The writer considers it a duty to place the subject of the test of the Belmont pumps in its proper light before the community, since erroneous statements once appearing in print are frequently reproduced, either by the design of interested parties or, perhaps from the unusual character of the merits of a machine so portrayed, and much damage may accrue from this if not corrected. All that I have essayed to do in the premises is to place the matter in its true light, as gleaned from the two reports, and leave the mooted subject for the just decision of our mechanical readers.

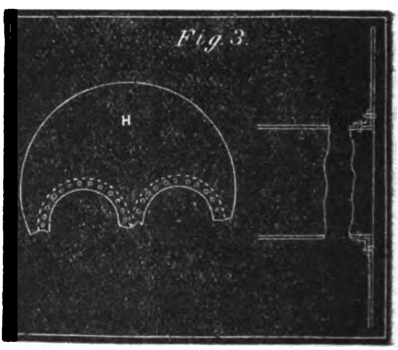
Philadelphia, Feb. 27, 1873.

ON THE STEAM-BOILER EXPLOSION AT THE ROLLING-MILL OF J. WOOD & BROTHER, CONSHOHOCKEN, PA.

By W. Barnet Le Van, Engineer.

The above works are situated on the west side of the Reading Railroad Company's track, and just below the bridge which crosses the same. The building covers a space of 100 by 200 feet. About one-half the works were destroyed by the accident, the upper end being a complete ruin, in which sections of the roof of the destroyed building, bricks, pieces of iron plates, twisted rods, bent bolts, lay in one confused mass. There were in the mill seven boilers, each being separate and distinct. The one that burst was at the northern end of the building, and its course was directly west across the canal.

The Exploded Boiler had been in use for nearly twenty years. When the rupture took place it was lifted from its settings, and shot across the canal like an immense projectile forced from a cannon, at about the same height as its original position, until it reached the building, 150 feet distant on the other side of the canal, known as the Albion Print Works. This immense mass, weighing about 5500 pounds, struck the end of a girder, twelve inches square, over an arched doorway, shattering the same, and tearing away the wall, and bringing up against a large cylindrical vessel of wrought iron, 8 feet in diameter and 12 feet high and $\frac{7}{16}$ of an inch in thickness, called a Kier, in which at the time were two lads, George Smith and James McNulty, who were arranging the pieces of endless muslin within by tramping them down so that the steam and lime-water, which were to be subsequently let in, would not mix up and entangle the material—the only mode of ingress or egress being a small man-hole on the top of the vessel. The two poor little fellows were tramping away when the end of the flying boiler came in contact with the sides of this kier. The heavy iron sides gave way before the shock like wetted paper—the indentation, nearly reaching the opposite side, instantly killing both lads, George Smith being actually cut in two. The force and impact of the blow of the flying boiler was so great that the piece of the wooden girder which

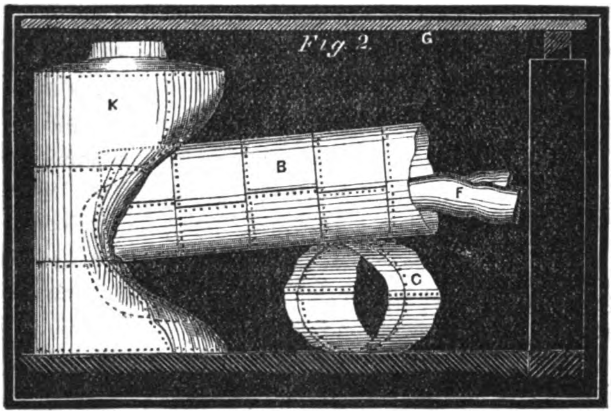


it carried with it was ground into splinters, and the atoms, being packed so closely together, were ignited by the friction that they burst into flames, setting fire to the material contained in the kier.

In the mill where the boiler stood eleven persons were killed and as many more wounded.

Nothing was left of the boiler at its original location except about two feet of one of the flues, the mud-drum and two-thirds of the back-head, H (cut 3).

The balance, consisting of the shell containing the two flues, lodged as above stated, in two pieces, as per sketch:



K, Kier.

B, Shell of boiler, contains the two flues, about 14 feet long.

C, Shell of boiler, about 4 feet long, open on both ends.

F, Flues.

Shell B represents the boiler with one end resting in the indentation of kier, the other end supported by a piece of the shell, C, about four feet long, 54 inches diameter, at right angles to shell B. After the boiler was removed, the hole in the side of kier was found to be about three feet in diameter.

The construction of the boiler is shown by the following cut:

Description of Boiler.—The boiler consists of a cylindrical shell, eighteen feet in length and fifty-four inches in diameter, and contains in its lower half two flues, each eighteen feet long and sixteen inches in external diameter, secured to the heads with angle iron rings. To the bottom, about three feet from the back end, was attached a mud-drum, eighteen inches in diameter, seven feet in length, by a pipe six

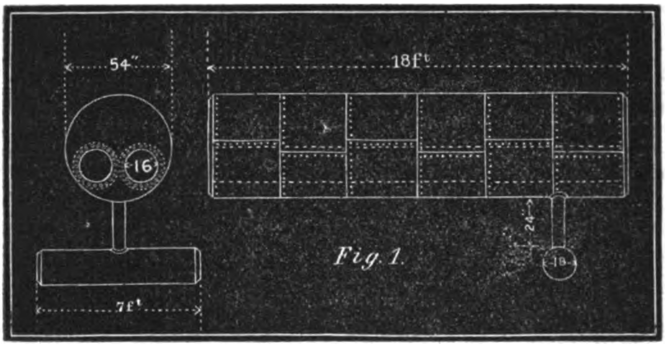


Fig. 1.

inches in diameter and twenty-four inches long, into which the feed-water was pumped. It was set, in the usual way, over the heating furnace, the waste heat of the latter passing underneath the shell, thence, through the flues, to a wrought-iron stack placed over the front end.

The following arc its principle dimensions and proportions, namely:

Extreme length, in feet, ...	18·
Diameter of shell, in inches, . . .	54·
Number of flues, ...	2·
Extreme length, in feet, ...	18·
External diameters of flues, in inches, . .	16·
Extreme length of mud-drum, in feet, . .	7·
External diameter, in inches, . . .	18.
Thickness of iron in shell, in inch, . .	·259 = No. 3.
Thickness of iron in flues, in inches, . .	·238 = " 4.
Thickness of iron in heads, in inches, . .	·454 = " 0000.

The safety valve was three and one-half inches in diameter, and in good order when found, after the explosion, as also was the three-inch stop-valve, the latter being closed. This valve was placed between the boiler and the main line of steam-pipe which conveyed the steam from all the boilers to the engine.

The flues at the point of rupture were but three-sixteenths of an inch in thickness, and as clean cut as if done with a pair of shears, allowing a ring of metal remaining in the angle iron ring, which secured the flues to the head as though it was so ordered. The flues were flattened together as though they were passed through a pair of rollers.

The iron composing the flue plates was very much crystallized at the point of parting, no doubt caused by the constant expansion and contraction; and there is no doubt but a certain amount of this crystallization was due the use of angle iron rings to connect it to the heads; the flue plates would not flange from its being *hot short* iron.

The boiler had been out of use for a few days for repairs, and they were in the act of getting up steam at the time of the explosion.

The Engineer's Statement.—The engineer testified that he had observed the fireman firing up at about two o'clock in the afternoon; the blast was put on the furnace at half-past two, another man having succeeded the first fireman; the explosion occurred at twenty minutes past four, the blast having been on the furnace until that time; there was no unusual forcing of the fires; witness had in the meantime tried the gage-cock and water-gage; usually carry about from eighty to eighty-five pounds on the gage; had about fifty pounds on about ten minutes before the explosion; never knew the safety-valve to stick; carried the weight on the lever of the safety-valve at about eighty-five pounds, at which pressure the boiler would blow off; noticed nothing unusual about the boiler; there had been no water in the boiler until the day on which the explosion took place; he pumped the water into the boiler right out of the river; there was no water in the boiler until half-past twelve on the day of the explosion; it generally took about three and a half hours to generate steam enough to run; the man who took the place of the one that fired up in the first place is among the killed; the boiler was nearly full of water; it blowed water from the top gage-cock; never was in the habit of hanging any weights on the safety-valve lever.

In answer to a question of a juryman, the engineer said that, to the best of his knowledge, there was not more than 55 or 60 pounds of steam pressure when the boiler exploded.

The Verdict.—"That the deceased (names mentioned) came to their deaths by the explosion of a boiler in the rolling-mill of J. Wood & Brother, in the above borough (Conshohocken), and, in the opinion of the jury, said boiler had by long and continued use become, in certain parts, inadequate to carry the required pressure, viz., eighty pounds."

Strength of the Boiler.—The shell of the boiler would have parted at 322 lbs. per sq. inch, taking the value of the plates, single-riveted, at 33,600 for its elastic limit. The *working pressure* should be, for safety,

at least one-sixth of the above, say fifty-three and one-half pounds per square inch. The flues would have collapsed, by Fairbairn's formula, at a pressure of one hundred and forty pounds per square inch, the safe working pressure being only twenty-three pounds. The shell, as will be seen by the above, is about two and one-half times the strength of the flues. The working pressure of the boiler, as stated by the testimony of the engineer, having been eighty-five pounds per square inch.

The Cause of the Explosion.—The cause of the explosion is therefore obvious, viz: weakness of the flues. No flues of such dimensions as those just given can be safely worked with steam at a pressure of eighty-five pounds per square inch, unless strengthened either with hoops or flanged seams, or stayed in some other suitable manner. It may be true, however, that some such flues, though unstayed, are working, and have done so for years with steam of an equal or even a greater pressure than the above; still they are continuing to do so only at a risk; and their past exemption from collapse is no security against its occurrence in the future. Thus it will be seen that the above explosion occurred from the most simple cause, and that no mystery whatever need be attached to it, while, by suitable construction of the boilers in the first place, and due attention to their state of repair in the second, explosions would in most cases be prevented.

Very few of the explosions that have come under my notice occur from low water, and I believe that to be a much-abused idea, and the number of explosions resulting from it to be much exaggerated. At inquests it is the general verdict, and the fireman being frequently killed, there is seldom any witness to the contrary. The greater number of explosions occur from the insufficiency of the boiler for its working pressure, either on account of its original construction, or state of repair consequent upon use; where it occurs from want of water, or from reckless pressure, explosions are rare. The majority of explosions are due more to the weakness of the boiler than to over-pressure of the steam. There is no plan of testing the construction or weakness of a boiler, either new or old, equal to the use of hydraulic pressure; its application is so simple, and the pump so small, that every boiler owner could at a small cost provide themselves with one. In fact the ordinary feed-pump could be used temporarily for that purpose and should be applied at least once a year. Weak places in the plates may pass undetected, even on careful examination, while some parts may be inaccessible and concealed from view; but the hy-

draulic test is sure to detect and expose them all. Its application in this case would no doubt have prevented this disastrous explosion.

The Examination of Boilers.—In all examinations of boilers, it should be done in person with the free use of a round-nose hammer on all the stays and flues, and when this has been done in a thorough manner, the hydraulic test should then be applied.

This is what you pay to have done in the case of the Boiler Insurance Company, should you apply to them for a policy of insurance on your boiler. The first outlay for this purpose would furnish you with a test-pump and the necessary appliances to repeat it every six months at a nominal cost; in fact, every one should be able to take his own risk.

Safety Factor.—In conclusion, I would call the attention of the Institute to the factor of safety for boilers as being entirely too low. The great number of disastrous explosions that have lately occurred in different parts of the country are the best evidences of the fact. The Bridge Engineers have long since come to this conclusion, and have fixed their factor of safety at one-eighth the ultimate value of the material.

The elastic limit of wrought iron of high quality is 33·600 pounds per square inch, making an allowance for the loss by rivets of ·56 per cent., we find for the elastic limit of a boiler shell that the factor would be 18816, or 33·600 pounds × ·56.

All experience has shown that but one-quarter of the elastic limit, say 5000 pounds, making all allowances for rivets or attachments, is all that ever should be used in practice.

February 19, 1873.

A Large Aneroid.—An immense aneroid barometer is about to be placed on the façade of the Paris Bourse. The portion, however, of the instrument which is sensitive to the various pressures of the atmosphere is no larger than the ordinary sized aneroid. The movements of the corrugated plate are transmitted to a train of clock work, by suitable mechanism. This last, which is wound up monthly, actuate a great needle on the exposed face, the latter being four feet in diameter.

TORSIONAL RESISTANCE OF MATERIALS DETERMINED BY A NEW APPARATUS WITH AUTOMATIC REGISTRY.

By Prof. R. H. Thurston.

While the classes of the Stevens' Institute of Technology were recently engaged in their revision of coëfficients, as given by various authorities on strength of materials, the difficulty of determining how far the differences noted were due to errors of observation, and how far to variation in the quality of the materials used, suggested to the writer the advisability of obtaining an apparatus which should make its own record. This could readily be done by so constructing it that a curve might be automatically registered at each tests, which should represent all circumstances of the experiment.

Such an automatic registry would evidently yield more reliable and instructive information in regard to the circumstances of distortion and fracture than could any system of personal observation.

Representing the magnitude of the distorting stress at every instant, and under every degree of distortion of the material, up to the limit of elasticity or even to the point of rupture, and exhibiting also the corresponding alteration of form at every point, the pencilled curve would be a record from which might be deduced the coëfficients of elasticity, strength and resilience, as well as the laws governing the relations of the distorting forces to the resistance of the material.

A simple but effective machine was therefore designed and constructed, which accomplishes satisfactorily the desired result, and this machine, as planned by the writer and constructed by Messrs. Hawkins & Wales, instrument makers to the Institute, is shown in Fig. 1.

As here arranged, it is intended for experiments on the torsion of materials. Its modifications, for the purpose of experimenting upon transverse strength, will be described in a subsequent paper, in which will be given the results of that series of experiments.

In the figure, the frame, A A, A'A', supports two suspended arms, C E, B D, which swing about independent axes in the same line. The arm, B, carries at its extremity a weight, D, and the arm, C, has a handle, E, by which it is moved. The axes of these arms are designed as shown in Fig. 2, each having a rectangular recess at L and at M, which receive each an end of the test piece, which is squared to fit, as shown in Figs. 3 and 4.

The frame, A′A′, carries a guide curve, F, of such form that its ordinates are proportional to the twisting moments exerted by the

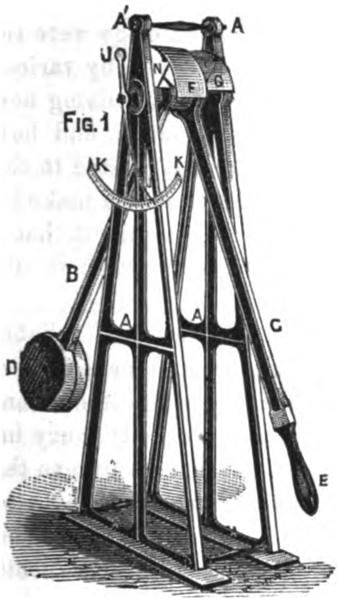


FIG. 2

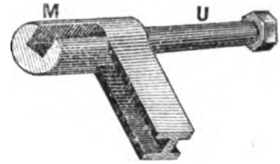


FIG. 3

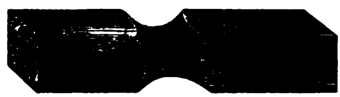
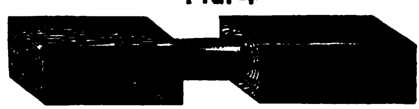


FIG. 4



weighted arm, B D, while swinging through the arc to which the corresponding abscisses are proportional. A pencil holder, I, bears against this guide curve, and, being carried by the weighted arm, is thrown forward, as that arm swings out under the action of the force producing torsion, which force is transmitted through the test piece.

The arm, C E, carries a table, G, and the pencil, I, therefore, traces upon the paper, which is clamped upon it, a curve, the ordinates of which are proportional to the torsional moments, while its abscisses represent the relative motion of the two arms, and, consequently, the amount of torsion to which the test piece has been subjected.

The curves thus described, of which the accompanying plate exhibits a number, present, in a very legible and convenient, as well as reliable, form, all the results of the experiments, of which they are the respective records.

The pointer, J, traversing the arc, K K, is arranged as a maximum hand, and affords a useful check upon the automatic record of maximum strength.

The plate represents the results of average experiments made upon a considerable number of varieties of wood, the test pieces of the form shown in Fig. 3 being used. The diameter of the neck of each piece was seven-eighths ($\frac{7}{8}$) of an inch.

This diameter happened to be that best adapted to use in this machine. A larger size was found, frequently, to yield by the destruction of lateral cohesion, the square head peeling, leaving a prolongation of the cylindrical portion, instead of twisting off in the neck. This size is convenient, also, in consequence of the fact that the coëfficient of ultimate strength for the standard diameter of one inch is obtained, with a close approximation to exactness, by simply multiplying the twisting moment for each piece by 1·5.

These curves exhibit the relative stiffness, strength and resilience of the woods tested very perfectly. The inclination of the straight line, forming the first portion of each diagram, from the vertical is a measue of stiffness; the height of the maximum ordinate indicates the ultimate strength; the point at which deviation from this straight line commences, determines the limit of elasticity, and the area included within each diagram is proportional to the torsional resilience of the test piece.

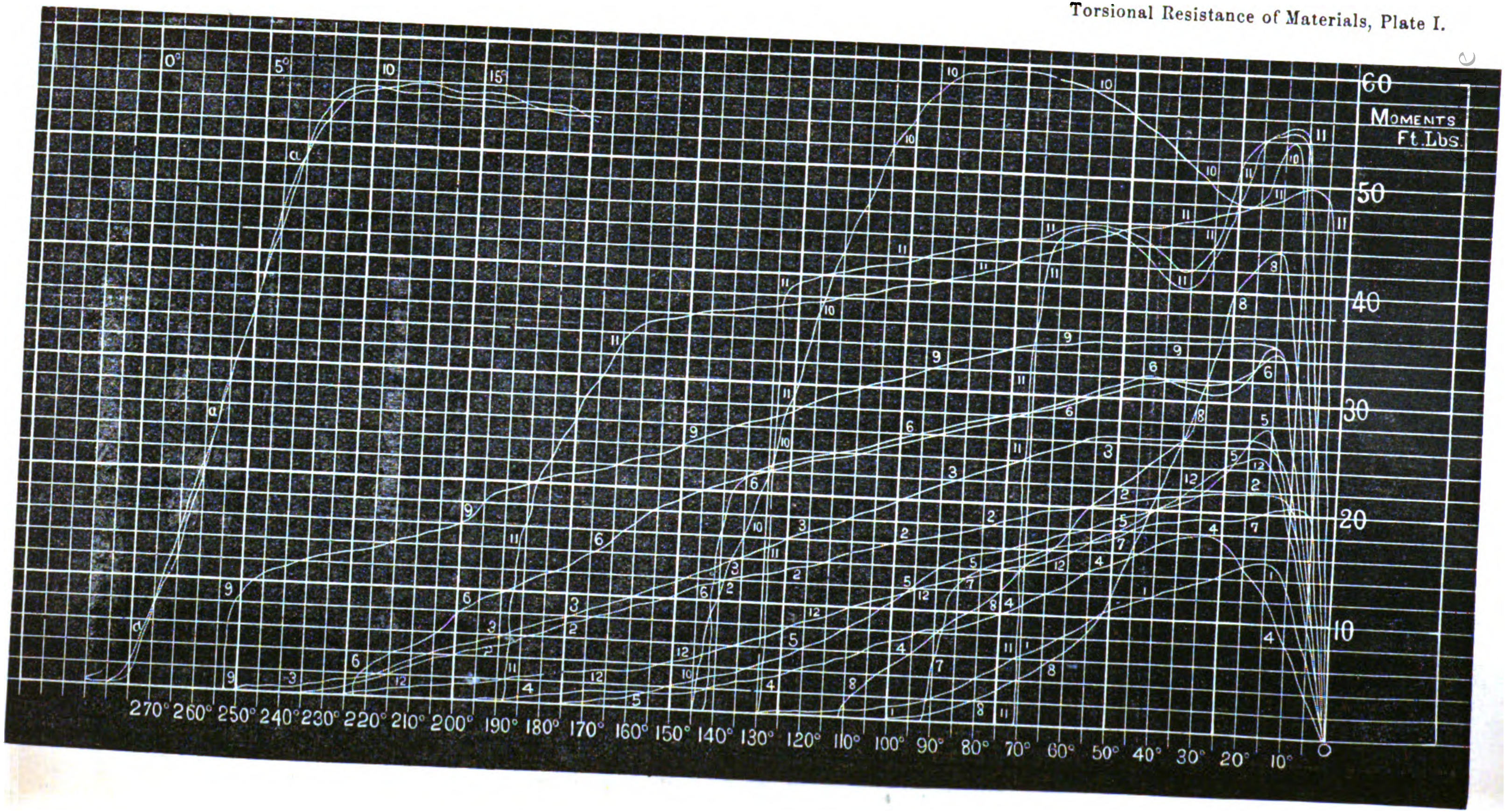
The fact that the commencement is, in each case, almost a perfectly straight line, is well exhibited in the curve, a a a, of locust, where the horizontal scale is purposely magnified, justifies the usual assumption that, up to the limit of elasticity, Hooke's law is correct, and that the angle of torsion is proportional to the twisting moment.

The short curve of small radius, noticed at the foot of the straight portion of each line, is produced by the slight yielding of the test piece by crushing, where it is grasped by the machine, which yielding continues until a firm hold has been secured.

It will be observed that, in most cases, the torsional resistance increases with the total angle of torsion up to a maximum, then, passing the limit of elasticity, it drops off more or less rapidly, returning finally to zero. In the brittle woods, the fall takes place suddenly, while, in the tougher and more elastic varieties, the resistance decreases very slowly, in some cases vanishing only after the test piece has been twisted through a very large angle.

In the case of black walnut, 6, 6, 6; locust, 11, 11, 11, and, in a still more remarkable manner, in that of hickory, 10, 10, 10, a striking peculiarity is exhibited, which is one of the most interesting and unanticipated developments of this series of experiments. In these

Torsional Resistance of Materials, Plate I.



curves the resistance increases with the amount of torsion, until a maximum is reached; the line then drops to a point considerably below, and thence again *rises* and passes another maximum, which, in the case of hickory, is only reached after a torsion of 75°. The resisting moment there becomes considerably greater than at the limit of elasticity.

This striking peculiarity was shown, by carefully repeated experiment, to be due to the fact that, in those woods in which it was noticed, the lateral cohesion seemed much less, in proportion to the longitudinal strength, than in other varieties. Watching the process of yielding under stress, it could be seen, by close observation, that, in the examples now referred to, the first maximum was passed at the instant when, the lateral cohesion of the fibres being overcome, they slipped upon each other, and the bundle of, then, loose fibres readily yielding, the curve dropped until, by lateral crowding, further movement was checked and the resistance again rose until the second maximum was reached. Here yielding again commenced, this time by the breaking of the fibres under longitudinal stress,—under that component of torsional stress which takes a direction parallel with that of the fibres in their new positions. In these cases rupture seems never to occur by true shearing in the transverse plane. The fibres part, one after another, the exterior ones breaking first, under a tensile stress.

The following varieties of wood have been subjected to torsional fracture, and the curves obtained are shown in the plate which illustrates this article:

1. White Pine, (*Pinus strobus.*)
2. S. Yellow Pine (*Pinus australis*), sap wood.
3. " " " " heart wood.
4. Black Spruce (*Abies nigra*).
5. Ash (*Fraxinus Americana*).
6. Black Walnut (*Juglans nigra*).
7. Red Cedar (*Juniperis Virginianus*).
8. Spanish Mahogany (*Swietenia mahogani*).
9. White Oak (*Quercus alba*).
10. Hickory (*Juglans alba*).
11. Locust (*Robinia pseudo-acacia*).
12. Chestnut (*Castanea esca*).

The curves, the *fac similes* of which are given in the plate, exhibit

well the relative values of the materials tested for the various purposes to which they may be applied.

White pine, 1, 1, 1, yields quite rapidly as the torsional moment increases, and the considerable inclination of the line from the vertical indicates its deficiency in stiffness. It soon reaches the limit of elasticity, and the diagram exhibits the maximum strength of the test piece, 15½ foot-pounds. Passing the limit of elasticity and the maximum moment of resistance almost simultaneously, its resisting power decreases rapidly, and with tolerable uniformity, until, at "a total angle of torsion" of 130°, it is twisted completely off. The area comprised within the curve is comparatively small and it is thus shown to have little resilience.

Yellow pine, in accordance with our already well established ideas of its properties, is found by an examination of its curve, 2, 2, 2, 3, 3, 3, to have much greater stiffness, strength and resilience. The sap wood, 2, 2, 2, is equally stiff, in the examples tested, with the heart wood, 3, 3, 3, 3, but sooner passes its limit of elasticity, the former circumstance being quite opposed to the preconceived ideas of the writer. Notwithstanding the comparatively low position occupied by the pines in our list, they are excellent materials, the yellow varieties particularly, for general purposes. Our comparison is made with specimens of equal size, and the important fact of the exceptional lightness of these woods is nowhere brought to our notice by these tests.

Spruce, 4, 4, 4, 4, is less stiff than white pine, even, but possesses greater strength and resilience, its moment of resistance reaching 18 foot-pounds, and twisting through a total angle of torsion of 200°.

Ash, 5, 5, 5, 5, seems to be weaker and less tough than is generally supposed; it is possible that the specimens tested were over seasoned. Its most striking peculiarity is its very rapid loss of strength after passing its limit of elasticity.

Black walnut, 6, 6, 6, 6, of the excellent quality and good condition, as regards seasoning, of the samples tried, is very stiff, strong and resilient, and is but little inferior to oak. Its resisting moment reaches 35 foot-pounds, and one specimen reaches a total angle of torsion of 220°.

Red cedar, 7, 7, 7, 7, is stiff, but brittle, and loses all power of resistance after twisting through an angle of 92°. A torsional moment of 20 foot-pounds only produces a total angle of torsion of 5°.

Spanish mahogany, 8, 8, 8, 8, is very stiff and strong. It is de-

ficient in toughness and resilience, losing its power of resistance very rapidly after passing the limit of elasticity.

White oak, 9, 9, 9, 9, has less torsional strength than either good mahogany, locust or hickory, but is remarkable for its wonderful toughness. It passes its limit of elasticity at 15°, but loses its resisting power very slowly indeed. We find the latter almost unimpaired until it has been subjected to a torsion of 70° ; it only yielded completely at 253°.

Millwrights are evidently perfectly correct in holding this wood in high esteem for strength, toughness and power of resisting heavy shocks and strains.

Hickory, 10, 10, 10, 10, exhibits, in its curve, the remarkable pair of *maxima* already referred to, and has, apparently, the highest ultimate torsional strength, combined with unusual stiffness and considerable resilience. Its moment of resistance to torsion reaches a maximum of 58 foot-pounds.

Locust, 11, 11, 11, 11, has greater stiffness than any other wood in our list, and stands next to hickory in strength ; it is, also, very resilient. Three diagrams are given, each of which possesses its own peculiarities. One specimen is only twisted through a total angle of torsion of 4° by a torsional moment of 48 foot-pounds.

Where more than one curve is given for the same wood, it is a fact worth noticing that the stiffness and ultimate strength are usually very nearly equal, and that the difference between the several specimens becomes marked, if at all, in their degrees of toughness.

In the formula for torsional strength, $Pa = Cd^3$, the curves give, values of C, as follows :

1. White Pine,	25	7. Red Cedar,	32
2. Yellow " sap,	35	8. Spanish Mahogany,	65
3. " " heart,	40	9. Oak,	53
4. Spruce	30	10. Hickory,	85
5. Ash,	48	11. Locust,	80
6. Black Walnut,	55	12. Chestnut,	35

Determining relative stiffness by obtaining values of the ratio of twisting moment to the total angle of torsion we obtain the following :

1. White Pine,	1·00	7. Red Cedar,	4·00
2. Yellow " sap,	2·25	8. Spanish Mahogany,	3·00
3. " " heart,	2·25	9. Oak,	2·53
4. Spruce,	0·67	10. Hickory,	4·15
5. Ash,	1.87	11. Locust,	5·50
6. Black Walnut,	2·63	12. Chestnut,	1·60

Taking the well established value for oak as a standard, we deduce the following values for the coëfficient to be used in the formula,

$$\theta = \frac{2\ Pa}{G\pi r^4} = \frac{\text{Total Angle of Torsion.}}{\text{Length of Part Twisted.}}$$

1. White Pine,	220,000	7. Red Cedar,	890,000
2. Yellow " sap,	495,000	8. Spanish Mahogany,	660,000
3. " " heart,	495,000	9. Oak,	570,000
4. Spruce,	211,000	10. Hickory,	910,000
5. Ash,	410,000	11. Locust,	1,225,000
6. Black Walnut,	582,000	12. Chestnut,	355,000

Finally, by measuring the areas of the several curves, we deduce the following values for relative resilience, white pine being taken as the standard:

The work done in twisting off these specimens is found to have relative values as follows:

1. White Pine,	1·00	7. Red Cedar,	1·61
2. Yellow " sap,	3·01	8. Spanish Mahogany,	2·25; 1·65
3. " " heart,	3·87	9. Oak,	6·60
4. Spruce,	1·50	10. Hickory,	6·90
5. Ash,	2·25	11. Locust,	7·65; 5·85; 320
6. Black Walnut,	5·00; 3·95	12. Chestnut,	2·40

The values of coëfficients, as given, will be checked by additional experiments upon test pieces of the form shown in figure 4, carefully turned to a diameter of $\frac{3}{4}$ inch, and of a length, in the neck, of one inch.

Coëfficients for metals will also be given in a later communication.

Stevens Institute of Technology, Hoboken, N. J., Feb., 1873.

A French Inventor proposes to photograph dispatches to microscopic fineness, and blow them through a tube sunk in the Straits of Dover. When at their destination the dispatches could be enlarged again. By this method long dispatches could be sent about as cheaply and expeditiously as short ones.

Chemistry, Physics, Technology, etc.

REPORT OF THE COMMITTEE OF THE FRANKLIN INSTITUTE ON THE CAUSES OF CONFLAGRATIONS AND THE METHODS OF THEIR PREVENTION.

The undersigned, a special committee appointed by the Franklin Institute to ascertain the causes and the best means of preventing conflagrations, have given the subject careful consideration.

During the past year there were, within the limits of Philadelphia, 603 fires, an alarming increase over the year 1871, of over 41½ per cent. Total loss by fire, $2,173,148.

Fifty-nine fires—the largest number originating from any one source—were caused by the explosion of coal oil and fluid lamps. The number of persons injured by these explosions and fires so as to cause death was about 100. 54 fires originated from downright carelessness, mostly with matches, gas and lamps; 51 by defective stove pipes, broken stoves, burning coal and wood falling upon the floor. 35 buildings were intentionally set on fire. 32 conflagrations were from spontaneous combustion; 24 originated from *tobacco-pipes* and *cigars*; 23 were caused by defective flues and 20 by fire works.

The use of petroleum in its various forms has been the most prolific cause of conflagrations. Hence the first section of our report this evening is on illuminating oils.

The best way of producing artificial light and heat is pre-eminently worthy the careful and profound consideration of the Institute. For these aids are the very source of all the mechanic arts. Without them society would revert to the level of the brute creation and the spontaneous productions of the earth. Hence, this subject has a legitimate paramount claim, for it is the very basis of the great cause of civilization. The use of petroleum is yet in its infancy. It is only thirteen years since its general introduction. Like gunpowder and steam, it has become indispensable. Like these, also, in the hands of knowledge, it is a faithful servant. In the hands of ignorance it is a dreadful master. Even in this city, proverbial for the intelligence of the great majority of the people, and where gas is so generally used, this illuminant has been the most fruitful cause of disastrous fires, and sudden, fearful, untimely death. In other cities, and

in the rural districts throughout the entire Union, the destruction of property and the death rate, in proportion to population, has been still greater. Ignorance and carelessness in the use of illuminating petroleum oils are the cause of the terrific conflagrations that, within scarcely more than the third of a generation, have probably destroyed more property and lives than were lost during the entire war of American independence.

The coal oil first introduced in the United States had a burning point of 124 degrees, and was used with great timidity and care. About 50 per cent. of the petroleum obtained from the wells, the light volatile product known as benzine, gasoline, &c., was thrown away, on account of the great danger of keeping it. The first demand for the light product was for chemical purposes and exportation; the price established for it at the wells was only two cents per gallon. Since that time it has gradually advanced, but has always remained much cheaper than the standard oil with its burning point of 110 degrees. Mixing any of the lighter forms of petroleum with oil that stands the Government test will greatly facilitate the lighting of old gummy wicks, and always increase the brilliancy and beauty of the light. Hence the retailer who uses the comparatively safe oil with a burning point of 110 degrees will be accused of keeping a poor article, and have his customers leave to buy of his neighbor, who, by adding benzine at about half cost, can sell a lower-priced oil, make more profit, and gain the reputation of keeping the best article the market affords. According to the present State law, no Government Inspector has the right to inspect or in any way prohibit the sale of any mixture of combination oils or combination burning fluids. The law expressly confines the State Inspector to coal oil and kerosene. The courts have decided that he has no jurisdiction over the sale of oils or fluids bearing any other name.

Hence, if the State Inspector should visit a retail store, and the proprietor has any doubt about the quality of his oil, he may claim that it is combination fluid, and if it should burn or explode even below the freezing point, the retailer is not only entirely exempt from the penalties of the law, but actually receives the plaudits of his customers for keeping an article so easy to light, so free to burn, and when actually on fire without confinement so readily to be extinguished. If the agents who traverse the country and set fire to volatile petroleum in a full, open lamp, were to permit it to be only partially filled with the fluid and remain long enough in a warm room to have the vacant

space in the lamp filled with the vapor or gas that is constantly emitted from the light petroleum or combination fluid at a high temperature, then an explosion would occur, the energy of which would be proportional to the amount of the mixture of the gas and atmospheric air. The State Inspector during the past year examined forty thousand barrels of coal oil and kerosene at wholesale stores, and there, through the defect of Legislative enactment, his labors ended. The rule will generally hold true that the more volatile the oil, the cheaper the fluid, the more dangerous the compound, the clearer and better the light. Hence the highly inflammable mixtures which yield most profit to the retailers and the most satisfaction to their customers are entirely beyond the scope of legal inspection. One of your Committee visited the dwelling at Morton station, where four persons were burned to death by the explosion of a can containing nearly a gallon of volatile petroleum or combination fluid. The room in which the explosion took place had a low ceiling, and a very large stove, which had been kept at nearly a red heat, in order to expedite a large ironing. There was no light or fire in the room except the one in the stove. A young lady was still conscious and lived long enough to describe her mother, who took the can of oil, removed the cork of the spout at the table, several feet from the stove. She instantly saw, on the removal of the cork, a flash go from the stove to the can, heard a loud, hissing noise, and that was all she remembered. A lady near the dwelling heard the explosion, and instantly saw the kitchen full of red flame. A gentleman near by ran to the rescue. About two minutes after the explosion the door was opened and the fire appeared to be extinguished. The can had been filled the day previous with a gallon of light petroleum, called combination fluid. Evaporation had been going on all day in the hot kitchen, from several lamps and the can. The room was evidently partly filled with the vapor of the fluid from the lamps, and the can, on the removal of the cork, a stream of vapor must have rushed from the spout to the strong draft at the stove, and, igniting, formed the stream of fire described previous to the instant explosion. The probable additional latent gas in the room also ignited and formed an intense heat that burnt the paper and paint of the room to a crisp in about two minutes' time.

We find by actual experiments that all the light forms of petroleum constantly generate vapor or gas even at the low temperature of 12 degrees above zero. This vapor, when properly controlled and managed, gives a clear white light, equal in brilliancy and beauty to the

best gas furnished by the city. But it appears impossible, in the present state of science, to use it with safety. No lamp can be made sufficiently secure to prevent the excessively volatile fluid from escaping from the lamp when it is not burning and the atmospheric air from filling part of the vacant space in the lamp after a part of the vapor has escaped or a part of the fluid has been burned. When the mixture goes on so that there is one part of gas and four parts of atmospheric air inside the lamp, or when these proportions exist in a room or any other apartment, they form a fearfully explosive mixture.

The number of deaths in the United States from the explosions of coal oil and fluid lamps for the year 1871 was, by the account kept by an insurance paper (the *Chronicle*), 3,500. If the death rate for 1872 kept pace with the increase of conflagrations, which was about 50 per cent., it would give for the past year 5,250 deaths, and the maiming of probably 20,000 persons within the jurisdiction of the United States. It is the peculiar characteristic of the explosive and exceedingly dangerous mixture of petroleum gas and atmospheric air to settle on the floor and remain there unperceived by either the sense of sight or smell. If there be no ventilation, and the supply of oil is abundant, the accumulation will go on till the apartment is filled from the floor to the ceiling. But the reverse is true with carburetted hydrogen gas furnished by the city, which will begin to fill at the ceiling and go down towards the floor; hence proper ventilation at the bottom and the top of every apartment where illuminating oils and gas are used tends to prevent explosions and conflagrations. It is always exceedingly dangerous to go into a close cellar or storeroom with a light or fire where vaporizing oils, burning fluids of any kind, or volatile spirits are kept. No family can retire at night with any degree of safety leaving cans of any of the light kinds of illuminating oils or burning fluids near a hot stove.

Any oil or burning fluid that evaporates rapidly or generates gas below one hundred degrees is exceedingly unsafe. It is easy for any one to determine the safety of any illuminating oil or fluid. First way: Take a small four-inch test tube, which can be obtained at a drug store for about five cents; fill it with the oil. If the evaporation in twenty-four hours exceed the fourth of an inch it is not safe. The best oil will remain for days without any perceptible diminution. If a test tube cannot be readily obtained, fill the fourth of a small teaspoon, pass a lighted match, or lighted taper, close to the oil or fluid to be tested, if it ignites at a surrounding temperature of less than one hun-

dred degrees it is totally unsafe to use about a dwelling. It is not the oil or fluid that explodes, but the vapor mixed with air. The act of carrying a lamp shakes the oil and facilitates evaporation. Also, the warmer the fluid the greater the amount of vapor evolved. Wicks of lamps after long use become conductors of heat. A burning wick turned down becomes a live coal, saves oil, and gives but little light, but always heats the metallic tube and collar, raises the temperature of the oil, increases its evaporation and consequent danger of *instant explosion*. Volatile oil and burning combination fluids generate vapor inside the lamp, hence the less the oil the greater the vacant space filled with vapor and atmospheric air, and the greater the danger, and hence it is apparent that to fill a lamp nearly empty while burning is almost certain to result in a terrific explosion. Extinguishing a lamp by blowing down its chimney increases the chance of explosion by igniting the gas inside. Light volatile oils are more dangerous to handle, where there is either light or fire, than gunpowder. The latter will only explode when fire is actually applied to it, but the vapor emanating from the former will, unseen, flow along a draft for many feet, and when least expected, as was the case at Morton station, form a train for instant overwhelming explosion and terrible loss of life. The present alarming condition of illuminating oils has been brought about by competition in business, and the general desire of the people to buy cheap. The fertility of resource, in the endeavor to utilize the lighter forms of petroleum, has added millions of dollars to the annual productive wealth of Philadelphia. Inventive power—the ennobling characteristic of free institutions—has caused petroleum to become the general illuminator, and Pennsylvania the oil emporium of the entire world. It has grown to be one of the largest items of commercial exchange between the United States and foreign nations—even India, China and Japan take petroleum for their products instead of gold. Safety to life and property are always of paramount importance. The quality of any oil or fluid is easily determined. Let the purchaser use the test-tube, or see if the oil in a small teaspoon can be lit with a match; if so, shun it as you would nitro-glycerine.

We recommend every one to try these safe, reliable tests before using any kind of petroleum illuminants, for, independent of the excruciating torture, long suffering and death that might befall the inmates of his own family, the conflagration may, by his neglect, at any time be wide-spread, as was the case at Chicago on the terrible

night of October 9, 1871. The labors of a life time may, by the explosion of a single lamp, be suddenly swept away by the irresistible besom of destruction. *Insurance companies, with millions of capital, may become bankrupt and lose their power as the faithful guardians of industry, the safe protectors of the unfortunate, the reliable endorsers of sacred legacies left to dependent widows and orphans—to institutions of learning and piety.* Hardly ever does a disastrous fire occur but many, by over-exertion and exposure, contract diseases that cause them, in the vigor and prime of life, to fill untimely graves.

The very best article the market affords ought to be bought by the poor as well as the rich, even if it costs 64 cents a gallon instead of 32 cents. The price will, even with the advance, be exceedingly low compared with former years before the introduction of the transcendently great and cheap illuminator which the world cannot now dispense with. By observing this golden rule the terrific disasters and conflagrations that have resulted from the use of the light, cheap forms of petroleum will hereafter be averted in this country, as they always have been, by observing stringent laws, in Continental Europe. Petroleum, properly managed, is a safe illuminant. The great cause of civilization cannot do without it. Inventive power may yet, by prudent management, render it the readiest, the safest and most desirable fuel in producing artificial heat for the mechanic arts and all the varied wants of man. The just value of the product of the oil wells of Pennsylvania for the year 1872 is upwards of fifty millions of dollars, or more than one-fourth the wealth of the entire agricultural productions of the State.

For full particulars we refer to the exhaustive report of the Secretary of the Institute, the ablest paper on the analysis and use of illuminants we have ever read.

In behalf of the committee,

J. B. BURLEIGH, Chairman.

The Light Petroleum Oils; Considered as to their Safety or Danger, in various Domestic Uses.

(*A Report to the Committee of the Franklin Institue, to inquire into the Causes of Conflagrations and the most efficient Methods for their Prevention.*)

Gentlemen:—In the field of illumination for public and domestic purposes, the direction of invention has been for sometime confined, not so much to the problem of creating new systems, as to the improvement of those already extant. Indeed, to one who fully appreciates the comprehensive advantages which coal-gas possesses for illuminating purposes, both æsthetically and sanitarily considered, and the elaborate conveniences which have been devised and so universally introduced, to render the details of its distribution and consumption perfectly automatic, while at the same time perfectly under control, the difficulties to be overcome by an innovator upon a field so thoroughly cultivated, will be comprehended.

Financial considerations, however, preclude the establishment of gas-works in locations other than large cities and towns—and for the benefit of those who are deprived of the luxury of coal-gas, inventors have most zealously striven. The development of the petroleum industry afforded a most effective spur to inventive genius, and has called forth a multitude of plans and processes for accomplishing this very necessary object. Of some of these it is the object of the writer, in the course of this report, to discuss the merits, as well as their bearing upon the score of safety. The composition and character of the petroleum oils are noteworthy, and the writer may hope to be pardoned for dwelling perhaps at too great length upon this point, since, otherwise, those who may not be conversant with the subject, will fail to comprehend the accuracy of any inferences which may be based upon them.

They are all of them composed of the elements carbon and hydrogen, and range, by imperceptible steps, from oils which are exceedingly light and inflammable to those which are heavy, thick, and viscous, and which can only be ignited at an elevated temperature. Nor is the material obtained from a certain locality to be regarded as a simple oil, since it is invariably a mixture of readily and difficultly inflammable oils. There is, of course, much difference in the appearance of the materials obtained from different locations—a fact most palpably manifested in their difference in gravity—but their general character is the same, whether found upon the shores of the Caspian

sea or in Pennsylvania. So numerous are the constituents of these oils, so closely do they resemble each other in their physical and chemical properties, that their separation and identification has afforded a problem which the skill of the chemist has thus far been baffled to solve; and the sum of our knowledge of them may be contained in the statement, that they consist of mechanical mixture of a great number of miscible hydro-carbons, whose gravities and boiling points increase by such imperceptible gradations that it is impossible to separate them, except roughly. For convenience sake, a number of commercial distinctions have been made, to which there is, at the present time, no valid reason to object. Of these, those which are known familiarly under the names burning oil or kerosene, benzine, and gasolene, alone concern the purpose of this paper.

Petroleum, according to Mr. S. Dana Hayes, State Chemist of Massachusetts, yields, by distillation, nine distinct products, as follows:—

Name.	Sp. grav. (Water, 1).	Sp. grav. Baumé.	Boiling point.
Rhigolene,	·625	—	65° Fahr.
Gasolene,	·665	85	120° "
C. Naptha,	·706	70	180° "
B. Naptha,	·724	67	220° "
A. Naptha,	·742	65	300° "
Kerosene Oil,	·804	45	350° "
Mineral Sperm Oil,	·847	36	425° "
Neutral Lubricating Oil,	·883	29	575° "
Paraffine,	·848 (?)	—	——

It must, however, be remarked, that the above figures express only the properties of the several products when obtained in as homogeneous a condition as it is possible to manufacture them commercially; and though under such circumstances the specific gravity of the oil affords a fair exponent of its inflammability, there can be no greater error than to trust to this as an infallible indicator of the quality of oils sold for household purposes.

Since this assertion may require explanation, it may be well to state that, owing to the perfect miscibility of all the petroleum products, it is possible, by simply mixing a light and a heavy product, to obtain an oil having a specific gravity ranging anywhere between the gravity of the two extremes of which it is composed. The temperature, however, at which such a mixture would evolve an inflammable

vapor, and that at which it would ignite, would be very materially affected; for such a mixture would not serve to neutralize the volatile qualities of the lighter oil.

An oil tested with the hydrometer might, for example, show a gravity of 45°13, but, instead of being a comparatively homogeneous oil, might be composed of a mixture of oils lighter and heavier, of which the indicated gravity simply showed the mean value. What is more important, however, such a mixture, instead of requiring a somewhat elevated temperature (about 120° F.), to evolve an inflammable vapor, as would be the case with a nearly homogeneous oil of this gravity, might ignite at all ordinary temperatures.

In regard to the inflammability of the petroleum products, two indications have been fixed, by which this quality may be conveniently estimated, and which at the same time afford the *only sure* indication of the safe or dangerous character of any of these products. These standards are called respectively the flashing and burning point. The first is the temperature at which the sample evolves an inflammable vapor; the second is that at which the oil itself ignites.

It will be evident, from what has been said, that we have here an infallible means of determining that which the hydrometer fails to indicate; namely, whether a sample of oil is a mixture, or is comparatively homogeneous.

Subjected to the first test, the lighter portions of the oil will successively rise to the surface, will be there converted into vapor, which, when evolved in appreciable quantity, will ignite with a succession of flashes on the approach of a lighted body.

If the sample is mainly composed of a heavy oil (whose boiling point is therefore high), this succession of flashes will be the only phenomenon at first observed; for the heat evolved from the momentary ignition of the lighter vapors given off, will not be sufficient to start the ignition of the whole body of oil. The temperature at which this phenomenon is first observed, is called the flashing point.

If the heating of the sample is continued, a temperature will soon be reached at which the remaining heavy constituent begins to evolve its vapors, which, when sufficiently rapid, will, upon being ignited, inflame the body of the oil itself. This temperature is called the burning point. By this test alone is it possible to determine the character of these miscible oils; and so certain are the indications which it affords, that in the several legal enactments with which it has been found necessary to surround the traffic in these oils, it has been relied upon to correctly indicate their quality.

In the preceding illustration, it appeared that the addition of a small quantity of light oil to a heavy one acted in such a way as to noticeably lower its flashing point. This action grows more marked as the amount of the adulteration increases, and will, when a very moderate dilution has been reached, also seriously affect the burning point of the mixture, the lighter portion of the sample being readily inflamed from the flash of the greatly increased volume of vapor which it throws off.

Dr. D. B. White, President of the Board of Health of New Orleans, found, for example, in experimenting with an oil which flashed at 113° Fahr., that an addition of

One	per cent.	of naphtha	caused it	to flash at	103°	Fahr.
Two	"	"	"	"	92°	"
Five	"	"	"	"	85°	"
Ten	"	"	"	"	59°	"
Twenty	"	"	"	"	40°	"

After the addition of twenty per cent., the oil burned at 50°.

It must be noticed that, though in general character the petroleum compounds are almost identical, yet, when considered in relation to their adaptability as illuminants, a marked distinction can be made.

The heavy oil boils at an elevated temperature, and at the ordinary temperature throws off only an inappreciable quantity of vapor. A lighted match, approached to an open vessel containing it, will not ignite it, and if plunged into the oil, it will be extinguished. With the other members of the series, however, the boiling-point is but a trifle removed from the ordinary temperature; and at the ordinary warmth of our dwellings, they are constantly throwing off volumes of vapor (the gasoline, of course, to a much greater extent than the naptha). A lighted match approached to an open vessel of either of them, will ignite them at once, and at some distance from the surface of the material.

It appears, therefore, that the light oils, owing to their extreme volatility, cannot be handled with the same indifference as the heavy ones. An open vessel, containing either of them, placed at some distance from the neighborhood of a flame, may, more likely than not, be the cause of sad mischief, and from a very simple cause. The vapor which it is constantly and imperceptibly giving off, flows from it in all directions, seeking the floor, in virtue of its superior density to the air—and once in contact with the flame—a flash—and the ignition arts, in an instant, back to its source.

Of the invidious, imperceptible nature of the dangers attendant upon their employment as illuminants, the public cannot be too clearly conscious, or too forcibly warned. And under no circumstances is the employment of these incendiary materials so severely to be condemned, as in the portable lamp so generally employed in the household. There are, it is true, circumstances under which they may be, with certain precautions, employed for other purposes than as lighting agents—and of these the writer will have occasion to speak further on—but, in the portable lamp, they may at any moment add another to the list of terrible accidents with which the public is already too familiar. Let the attention be but for a moment directed to the state of things involved. The body of the lamp is invariably of glass, and hence fragile. It is supposed to contain some of one of the lighter oils, the peculiar properties of which have just been alluded to. In the process of burning, the metallic attachments of the lamp will communicate sufficient heat to the body of the oil within, to fill the whole of the space above the oil with its vapor. So long, now, as the lamp remains unbroken, and its attachments without leakage, this circumstance is of little consequence, as, of itself, the confined vapor cannot be made to explode or ignite. But suppose the lamp, in this condition of things, to be shattered by a fall—a circumstance by no means infrequent—the consequence will inevitably be that the inflammable vapor in the neighborhood of the flame would at once ignite, and with it the whole body of oil in the lamp, to the imminent peril of person and property. Or suppose the equally probable circumstance, that the lamp, as before, should be refilled while burning, when the result might be, if possible, more disastrous than in the preceding case; for the volatile and inflammable vapors filling the upper portion of the lamp would inevitably, by their rapid diffusion into the air immediately surrounding the flame, form an explosive mixture, from the effect of which the lamp and its burning contents would be scattered in all directions. Where the oil made use of is one of proper quality, neither of the accidents here hypothetically stated would be possible, since, in no case, with a properly constructed lamp, could there be generated within the body of the lamp an amount of vapor sufficient to cause an explosion; nor could the oil itself be ignited at so moderate a temperature.

It is simply to be set down to good fortune, if one who has employed these oils for household purposes has escaped scot free, since no amount of care can avail against the inevitable result which must

follow one accident. It is easy to understand how persons ignorant of the highly dangerous character of the light petroleums may unknowingly make use of them in the manner above named; but it is really a matter of concern and surprise that so many, even of those who are thoroughly aware of the nature of the incendiary they are introducing into their households, are, nevertheless, thoughtless or indifferent enough to continue the suicidal practice—for no term can be too strong to properly characterize the fearful nature of the risk one is constantly running while employing these oils in the household.

There is, unfortunately, such a thing as too much legislation, as most communities are unfortunately aware, but there would seem to be no grounds for such a complaint on a subject which so intimately concerns the safety of the individual and the general public, as just this one. There are, it is true, laws which are intended to regulate the sale of this material, an inspection of its quality, and severe penalties, on paper, designed to punish those who sell, for illuminating purposes, an oil which will inflame below a temperature fixed by law at 110° Fahrenheit. But, most unfortunately, the legislation on the subject utterly fails to accomplish the end for which it was intended, namely, to protect the great body of the people, who are not supposed to be familiar with the nature of these materials, from the possibility of unknowingly running into such dangers as those which the writer has endeavored to make clear in what has preceded. And this lamentable state of affairs is due to the fact that the powers of the Inspector are limited to the examination of oils which are sold as refined petroleum, thus placing the host of dangerous patented compounds now flooding the market beyond his control—and from the fact also that the inspection is made *before* the oil leaves the hands of the wholesale dealer, and not after it has passed into the hands of the retailer, where it commonly is adulterated with a fair proportion of benzine. The temptation to this reckless practice is to be found in the fact that the benzine or naptha is considerably cheaper than the kerosene; and to this fact, as much as to the first named evasion, and insufficiency of the laws on this subject, is to be ascribed the host of misfortunes, which of late have multiplied with such alarming frequency as to horrify our public into serious consideration of the dangers they were unconsciously running.

An average crude oil contains—

	Per cent.	Price per gallon wholesale.	Price per gallon retail.
Cymogene, Rhigolene,	2	$1·50.	
Gasolene,	1·5	48 to 35 cents.	
Naphtha,	10	5 to 7 cents.	12 to 20 cents.
Benzine,	4	12 to 16 cents.	16 to 20 cents.
Kerosene,	55	20 to 25 cents.	30 to 40 cents.
Paraffin,	19·5	14 to 18 cents.	

Of these products, a very considerable proportion (about 15 per cent., as shown by the table) consists of the benzine or naphtha, and for this the demand in the various industrial arts is by no means equal to the supply; in consequence of which it commands but an inferior price in the market; in fact, considerably less than that demanded for the burning oils proper. Here, then, exists a direct temptation to dishonest or ignorant manufacturers and dealers to adulterate their stock of burning oil with oils of inferior price and dangerous quality. To what extent this reckless practice is carried on, the community have no just conception, but the writer feels safe in asserting that it is as general as any of the trade adulterations. The assertion is based upon the results of a large number of examinations into the character of oils from various portions of Philadelphia, sold to the public as burning oils; an examination which revealed the startling fact that, of a number of samples thus tested, only a trifling per centage of the whole number passed the ordeal of the fire test. In other words, the oils were, with the very few exceptions indicated above, simply burning oils, more or less liberally adulterated with benzine. How far these facts will go to explain the too often repeated instances of "coal oil horrors," the intelligent reader will be able to judge for himself. And it is certainly a melancholy species of consolation to know that what has been here shown to be true of Philadelphia, is true, also, of other large cities and towns. As an indication of the condition of things existing elsewhere, the writer would refer to the recently published annual reports of the fire inspectors of neighboring cities, in which attention is called, in most earnest terms, to the unusually large proportion of fires, accompanied, at times, with loss of life, during the year just passed, which were ascribable to petroleum; tracing them directly to an utter disregard for and inadequacy of the laws designed to protect the public against the danger of employing the light oils for household purposes.

From a recently published tabulation by the Fire Marshal of the city of Baltimore, it appears that out of 63 samples of oils, collected from various quarters of that city, but eight, or less than 13 per cent. of the whole number, were found to stand the fire test; and, as the laws regulating the traffic in these products have suffered no material modification since its publication, it is fair to conclude that this statement represents the average quality of the oils sold in that city to-day, if, indeed, an investigation should not show a yet lower percentage.

The writer regrets that it is not in his power to add to the above the results obtained by Prof. Chandler in his recent report to the Board of Health of the city of New York, a report replete with valuable information upon this subject, since that portion of the report relative to this item has not yet appeared in available form; but, from the tenor of the portion already made public, there can be no doubt that the results of his examination into the quality of the New York oils will strengthen that above quoted.

The following table gives the results of the examination made by the writer, in connection with Dr. T. R. Wolf, of Delaware College, of a number of samples of oils furnished by Dr. J. B. Burleigh, Chairman of your Committee, as having been obtained from various dealers, wholesale and retail, in this city and its neighborhood, and which may therefore be fairly considered to represent the average quality of the oils our citizens are using in their households:

No. of Sample.	Spec. Grav. Baumé.	Flashing Point. Fahr.	Burning Point. Fahr.
1	46°	84°	86°
2	46·5	74	86
3	65	54	54
4	66	51	51
5	64	55	55
6	48	117	120
7	64	54	54
8	45	74	86
9	64	54	54
10	70	51	51
11	46	89	100
12	48	64	75
13	46	93	100

No. of Sample.	Spec. Grav. Baumé.	Flashing Point. Fahr.	Burning Point. Fahr.
14	63	52	52
15	70	54	54
16	70	54	54
17	48	55	61
18	63·5	52	52
19	64	52	52
20	46	97	106
21	64	54	54
22	46	85	92
23	47	84	95
24	25	above 300	above 300
25	46	146	156
26	48	128	136

Most of these samples, notably Nos. 7, 9, 10 and 12, were obtained from firms who drive an extensive trade in retailing to small dealers; and establish the character of the material which is sold by the quart or pint at at least five thousand shops and stores throughout this city and its neighborhood. These prove to be amongst the most dangerous of any of the tested samples. That, however, which adds a peculiar interest to these specimens, is the fact that they are extensively advertised as safe oils, under specious names which disguise from the public their highly dangerous character.

Taking into consideration the extensive sale of the tested samples—as well as the fact that three of the four which were found to pass the government standard (Nos. 24, 25 and 26) were head light oils, which are rarely used in the household, but are mainly confined to railway use, lanterns, &c.—the proportion of safe oils really in common use by this public is so small as to be worthy of the gravest consideration. Including the oils just excepted, the proportion of safe oils used in our midst would be practically about one-twelfth of 1 per cent. An examination of the ten oil samples sold in the City of Wilmington, Del., by Dr. Wolf, shows a better result, the proportion of safe oils reaching as high as 12 per cent. It is probable, however, in view of the results published from other localities, that this showing is exceptionably favorable.

There seems to exist a notion that the explosive or inflammable properties of the light petroleums can be effectually neutralized by

adding various substances to them. The Patent Office records for the past few years contain numbers of claims for such mixtures of naphtha or gasolene with a great variety of substances, too numerous to mention.

Whether or not the inventors of these recipes really have faith in the claims they present is a matter of small importance; but the deceptive illustrations which they are able to offer in vindication of their assertions, no less than the attractive names which they attach to their incendiary mixtures, are the fruitful sources of many distressing calamities.

There is one simple and, for practical purposes, satisfactory method of determining the character of all such mixtures, and which applies equally as well to the common oils. Let a few drops be poured into a saucer, and apply a match; if the material burns, reject it as unsafe. The fact that the material can be set on fire at the ordinary temperature of our dwellings should be a sufficient evidence to a person of ordinary intelligence that, when employed in the household for heating or lighting purposes, it may, at the first thoughtless or careless act, become the cause of a frightful accident.

Hanging or stationary lamps of great variety of form and design have been constructed for burning these light compounds; gas and vapor stoves in similar variety have been introduced for household heating and cooking; but all of them should be shunned like the plague, and left severely alone.

In addition, another question of much practical importance presents itself, namely, What is the temperature to which the oil within the body of a lamp is heated while being consumed? From what has already been presented for your consideration it will require no explanation to assert that no oil is safe which can under such circumstances be heated above its flashing point.

For your inspection I append herewith several tables, containing the results of an extended examination of this branch of the subject, published with the recent report of Dr. Chandler, before alluded to.

For the sake of completeness, similar experiments, though not upon so extensive a scale, were conducted by the writer, which fully confirmed the results herewith quoted.

These results indicate that with lamps in common use the temperature of the oil within may even rise above the point fixed by law as the temperature of safety, and furnish excellent reason to urge, as does the author of the tables, that the laws upon this vital subject

should fix the flashing point of the oils used in the household at 120° Fahr., instead of at 100° Fahr., as is nominally the case at present.

THE TEMPERATURE OF OIL IN BURNING LAMPS.

First Series.—*Temperature of the Room* 73 *to* 74° *F.*

No.	Kind of Lamp.	Capacity of Lamp.	Temperature of the Oil. After one hour.	After two hours.	After four hours.	After seven hours.	Average for the seven hours.
	Air of the room........	....	73°	73°	74°	74°	74°
1	Brass hand lamp	8 oz.	85	82	85	86	84·5
2	Brass hand lamp	24	79	83	84	82	82
3	Glass stand lamp	8	77	78	79	80	78·5
4	Glass stand lamp	11	77	81	84	82	81
5	Glass stand lamp	20	78	79	79	80	79
6	Glass stand lamp	7	82	80	85	84	82·75
7	Glass stand lamp	10	84	86	84	82	84
8	Glass hand lamp	9	79	78	85	85	81·75
9	Glass hand lamp	6	81	82	86	86	83·75
10	Glass hand lamp	7	80	78			79
11	Brass student lamp	13	82	80	83	84	82·25
12	Glass stand lamp	10	81	81	79	78	79·75
13	Brass stand lamp	11	92	89	88	86	88·75
14	Tin lantern	7	89	86	88	87	87·5
15	Glass bracket lamp	19	82	82	84	83	82·75
16	Glass stand lamp	29	82	80	80	84	81·5
17	Brass student lamp	7	80		88		84
18	Brass stand lamp	14	84	85	87	87	85·75
19	Brass stand lamp	12	100	100	92	91	95·75
20	Metal stand lamp	9	82	82	88	87	84·75
21	Brass stand lamp	12	91	92	88	85	89
22	Bronze stand lamp	16	83	76	79	85	80·75
23	Glass hand lamp		79	80	82	82	80·75

"With the air of the room at from 73 to 74° F., the temperature of the oil in the burning lamps ranged from 76 to 100° F., the highest temperature of 100° having been reached in a metal lamp at the end of one hour. That this was an exceptionally high temperature is shown by the fact that the highest temperature reached in any other lamps was 92° F. The following is a synopsis of the observations:"

	23 Lamps.	11 Metal Lamps.	12 Glass Lamps.
Highest temperature reached,	100°	100°	86°
Lowest " "	76	76	76
Average temperature,	83	86	81

SECOND SERIES.—*Temperature of the Room* 82 *to* 84° *F.*

No.	Kind of Lamp.	Capacity of Lamp.	TEMPERATURE OF THE OIL. After one hour.	After two hours.	After three hours.	After four hours.	Average for four hours.
	Air of the room..	....	82°	83°	84°	83°	83°
1	Brass hand lamp	8 oz.	92	95	96	95	94·5
2	Brass hand lamp	24	88	94	94	93	92·25
3	Glass stand lamp	8	84	88	86	84	85·5
4	Glass stand lamp	11	84	86	86	84	85
5	Glass stand lamp	20	85	86	87	86	86
6	Glass stand lamp	7	86	87	88	88	87·25
7	Glass stand lamp	10	88	87	89	88	88
8	Glass hand lamp	9	87	90	90	90	89·25
9	Glass hand lamp	6	87	91	89	87	88·5
10	Glass hand lamp	7	84	86	86	84	85
11	Brass student lamp	13	86	88	88	88	87·5
12	Glass stand lamp	10	85	86	86	85	85·5
13	Brass stand lamp	11	104	103	101	101	102·25
14	Tin lantern	7	95	96	94	96	95·25
15	Glass bracket lamp	19	84	85	84	84	84·25
16	Brass stand lamp	29	84	85	84	84	84·25
17	Glass student lamp	7	87	88	86	84	86·25
18	Brass student lamp	14	91	93	92	91	91·75
19	Brass stand lamp	12	101	100	98	96	98·75
20	Metal stand lamp	9	89	92	94	93	92
21	Brass stand lamp	12	88	98	94	96	94
22	Bronze stand lamp	16	82	88	88	89	86·75
23	Glass hand lamp	6	84	86	85	84	84·75
24	Brass student lamp	10	120	120	120	118	119·5
25	Brass student lamp	12½	112	115	115	116	115

"With the air of the room at from 82 to 84° F., the temperature of the oil in the burning lamps ranged from 82 to 120° F. The temperature 120° was exceptional, being confined to one lamp. The following is a synopsis of the observations:"

	In 23 Metal Lamps.	In 12 Glass Lamps.	In 25 Lamps.
Highest temperature reached,	120°	91°	120
Lowest " "	82	84	82
Average " "	96½	86	91½

THIRD SERIES.—*Temperature of Room* 90 *to* 92° *F.*

No.	Kind of Lamp.	Capacity of Lamp.	TEMPERATURE OF THE OIL.				
			After one hour.	After two hours.	After three hours.	After four hours.	Average for four hours.
	Air of the room.......	....	92°	90°	92°	90°	91°
1	Brass hand lamp	8 oz.	90	98	100	98	96·5
2	Brass hand lamp	24	89	98	102	100	97·25
3	Glass stand lamp	8	88	90	93	94	91·25
4	Glass stand lamp	11	88	92	94	94	92
5	Glass stand lamp	20	85	92	94	94	91·25
6	Glass stand lamp	7	90	94	96	93	93·25
7	Glass stand lamp	10	90	96	96	96	94·5
8	Glass hand lamp	9	88	95	98	98	94·75
9	Glass hand lamp	6	89	95	96	97	94·25
10	Glass hand lamp	7	88	92	93	94	91·75
11	Brass student lamp	13	89	100	102	102	98·25
12	Glass stand lamp	10	88	92	93	93	91·5
13	Brass stand lamp	11	106	114	116	110	111·5
14	Tin lantern	7	99	106	107	105	104·25
15	Glass bracket lamp	19	85	92	91	91	89·75
16	Glass stand lamp	29	86	91	92	92	90·25
17	Brass student lamp	7	92	99	100	100	97·75
18	Brass student lamp	14	94	100	100	100	98·5
19	Brass stand lamp	12	108	112	112	107	109·75
20	Metal stand lamp	9	91	96	100	99	96·5
21	Brass stand lamp	12	104	110	108	106	107
22	Bronze stand lamp	16	84	90	95	98	91·75
23	Glass hand lamp	6	90	92	94	94	92·5
24	Brass student lamp	10	124	129	129	128	127·5
25	Brass student lamp	12½	120	126	127	127	125

"With the air of the room at from 90 to 92° F., the temperature of the oil in the burning lamps ranged from 84 to 129° F. The highest temperature being exceptional. The following is a synopsis of the observations:"

	In 25 Lamps.	In 13 Metal Lamps.	In 12 Glass Lamps.
Highest temperature observed,	129°	129°	98°
Lowest " "	84	84	85
Average " "	98¾	104½	92½

"By these results it appears that the temperature of oil in lamps often rises much above 100° F., thus reaching a temperature at which oil, *which does not emit a combustible vapor below* 100° *F.*, would be dangerous. It is apparent that 100° F. is too low a standard for safety; 120° F. would not be too high a standard, and its adoption would add but a few cents per gallon to the cost of the oil."

In view, therefore, of the facts here set forth, there would seem to be but one remedy available to the thinking portion of the community, namely, to urge the legislative bodies, with all the earnestness which the gravity of the existing condition of the subject demands, to make, with the least possible delay, such amendments to the laws regulating the sale and inspection of the petroleum oils, as shall render inspection a reality instead of a farce, which shall positively prohibit the sale or use of the dangerous petroleum products for household heating or illuminating purposes, and which shall punish with a severity commensurate with the gravity of the offence any violation of them, whether committed through ignorance or intention. The remedy here suggested could simply be reached by a judicious modification of the existing laws; and their vigorous enforcement would prove an effectual barrier against the sale of the adulterated stuff which now provides almost every household with a treacherous, insidious enemy.

Continuing the consideration of the modern innovations in the field of illumination, certain methods, by which the light oils of petroleum (gasoline especially) are made use of, to improve the illuminating power of ordinary burning gas, warrant attention. These processes are essentially the same in principle, though differing very greatly in the details of the devices in carrying out the idea; and when carried into effect, with certain obvious precautions, which will be referred to hereafter, are, to some extent, though by no means entirely, free from the vital objections on the score of danger, upon which so much stress has been laid in the preceding pages of this report. And the writer begs leave, once for all, to state his firm conviction, that it would prove a matter of inestimable benefit, if some method should be discovered and applied, either for converting these

volatile bodies into useful and harmless compounds, or if some process should be devised for utilizing them largely in the industrial arts. By either of these remedies the direct employment of the light oils for household illumination could be altogether avoided; since, though the ingenuity of invention may be exercised to devise preventives and precautions against accident with them, it is very gravely to be doubted, from the very nature of the materials, whether they can ever be so employed with a reasonable degree of safety.

The philosophy of the processes here referred to will be more clearly understood by a general reference to the principles involved in the utilization of illuminating agents. These are generally compounds of carbon and hydrogen, the so-called hydro-carbons, and are either already in the gaseous state, or are converted to this condition in the process of burning. A certain proportion of these elements is, however, necessary, in order that the illuminant shall burn with proper brilliancy. To the hydrogen of the burning body is to be mainly ascribed the heating power of its flame, while to the carbon alone are we indebted for its illuminating qualities. It is, therefore, possible that a hydro-carbon may possess too much hydrogen in proportion to its percentage of carbon (as is the case with the light carburetted hydrogen, for example), when the effect will be that of a hot flame, but almost or entirely blue, and with little or no light-giving power. Or, on the other hand, the burning body may contain an excessive proportion of carbon (as is the case, for example, with turpentine oil), when the result will be a dull red, dirty, smoking flame, which, though giving out more light than the first, is utterly objectionable on the score of the abomination of its smoke. It is, therefore, a matter of the first importance that, in an illuminant, these essential constituents shall be present in such proportions as shall produce the best illuminating effect.

With the common burning gas, the reason of its very general inferiority is to be referred to the large percentage of the light carburetted hydrogen gas and of free hydrogen itself, which it contains. The rationale of the introduction of these feeble or non-illuminating ingredients into the gas is not difficult to comprehend if a glance be taken at the operation of its manufacture.

In the process of obtaining burning-gas from fat coal, which is the one almost universally employed in gas-works, the rich, light-giving gas is evolved during the earlier portions of the heat; but, owing to the natural desire of the companies to secure from a charge the largest

quantity of gas, the heat is continued for a considerable time after the richer portions of the gas have passed off; the consequence of which is, that the gas passed over in the holder during this period is very largely composed of hydrogen, which has no illuminating power, and of the light carburetted hydrogen, which is not much better.

The fact that the gas supplied for household consumption is generally but of indifferent quality, mainly from the cause specified above, has originated a number of plans for improving its brilliancy, by supplying it indirectly with a portion of the constituent in which it is lacking, namely, carbon. This process involves the passage of the gas, before consumption, through a reservoir of some one of the light petroleum oils, preferably gasoline, on account of its eminent volatility; by which treatment it becomes charged to saturation with the vapor of this material, the illuminating power of which is very superior, and comes to the burner greatly improved in quality.

This process, which bears the name of "carburetting," has received, in several cities, a limited introduction. The volume of the gas is by this process considerably increased, as well as its illuminating power; and this, together with the cheapness of the carburetting material, the smaller quantity of gas which need be consumed to produce a given amount of light, as compared with that which would be required without its presence, combine to considerably diminish the expense of employing gas—an item, it must be granted, of no inconsiderable importance in large establishments where a large number of burners are regularly in operation. And it is in such establishments that this plan, or others, which will presently be alluded to, have been received with the most favor.

Where a limited number of burners are in requisition, as in smaller workshops, stores or private dwellings, the saving which may thus be effected in the item of expense, is scarcely a matter sufficiently important to offset the disagreeable routine of attention which it is necessary to devote to the apparatus to keep it in effective operation. Other incidental difficulties, such as the natural hesitation on the part of those familiar with the unavoidable risk entailed upon the handling of the carburetting material, and perhaps the still more cogent reason, that the insurance interests have, in most localities, prudently refused to sanction or permit the introduction of the process, in connection with risks assumed by them, have so combined to limit the application of the process of carburetting, that it is, though not new, still comparatively unknown to the general public.

Although the introduction of any of the lighter oils of petroleum into buildings for illuminating purposes will be discountenanced by all who seriously and candidly reflect upon the unavoidable risks which attend their employment, it must still be granted that, if these substances are to be employed at all, this and allied plans, in which the inflammable material is securely confined in a metallic reservoir, is infinitely to be preferred to the practice of using them in the lamps or stoves.

In connection with the modern processes for the utilization of the light petroleum oils, there remain yet to be reviewed a number of plans by which this is accomplished directly; although, through the intervention of appliances considerably more complex than the portable lamps. Reference is here made to the numerous devices which are popularly termed gas machines.

These consist, in general terms, of a reservoir, generally a strong metallic vessel, supplied with the oil to be utilized, through or over which a regulated supply of air (or in some cases of hydrogen) is passed, the illuminating agent resulting from this contact being then led, by the usual distribution-pipes, to the burners. In the simplest form of apparatus operating upon this principle, this result is accomplished by permitting the gasoline vapor, which is considerably heavier than the air, to fall, in virtue of its gravity, down a descending pipe, and thus, by the current established, induce a flow of air over the surface of the oil. The material is suitably contained within a reservoir provided with an opening at one extremity, to permit of the access of the air, and further, with a series of alternating, imperfect partitions. The object of the latter is to increase the amount of contact between the entering air and oil, and to effect what would be equivalent to a large evaporating surface. The more rapidly the gas is consumed from the burners, the more rapid will be the evaporating process, which will, of course, cease as soon as the burners are turned off. Thus, by ingeniously taking advantage of the extreme volatility of the light oil, an air-current is induced, by which an abundant supply of excellent illuminating gas is obtained automatically, without the introduction of any appliance other than the reservoir with its simple partitions. This plan, though very interesting, from its simplicity and the scientific principle which it so ingeniously illustrates, involves the serious necessity of placing the reservoir of oil in the upper story of the building to be lighted. It contains the essential features, though the object is attained in the simplest possible manner, of all the numerous gas-machines. In the others, a fan or its equivalent is employed to

blow into the reservoir a stream of air. Though somewhat more complex in construction, this form of the apparatus is less objectionable than that first described, from the fact that the reservoir of oil may be located at a considerable distance from the house, and beneath the ground, in a pit prepared for the purpose—thus lessening the risk by lessening its proximity to the building endangered by its presence; though, with all of them, the personal dangers attending the replenishing of the reservoir, remain the same, as does also the liability to explosion, when a leakage occurs or from an accidental deficiency of oil in the reservoir, or extremely cold weather, a defect in the proper working of the apparatus, or from any other cause, an excess of air is introduced by the blower. Where such a condition of things occurs, an explosion is the inevitable consequence, since the instant the proper mixture of air and vapor is reached, the combustion of the gas at the burners will dart instantly back to the reservoir with all the explosive violence of gunpowder.

With the hydrogen machine, where a current of hydrogen gas (generated, in an appropriate vessel, from the action of diluted sulphuric acid upon iron scrap), is passed through the reservoir of oil, though it seems not to be so liable to an accident from this source, and affords a light much superior to that obtainable with the other forms of machine, is more obviously objectionable, on the score of complexity of the operations involved in its working, not the least of which consists in the replenishing, from time to time, of the generating vessel; an operation which, from the character of the acid and its refuse, is a most disagreeable one. Another objection, however, which far more effectually extinguishes the possibility of this process ever gaining popularity, resides in the fact that the gas obtained by it costs, to say the least, three times as much per thousand feet as the ordinary burning gas. The sale of the refuse to the manufacturing chemist, for the extraction of the green vitriol, and the diminution in the quantity of gas consumed, by reason of its excellent illuminating quality, may effect a slight reduction in the grave item of expense, but this will, even under the most favorable circumstances, be too great to permit of any other than a very limited introduction.

With this somewhat lengthy consideration, the gas machines may be passed by; though, in conclusion of this branch of the subject, a few words upon their merits may not be thrown away.

They possess, one and all, the objectionable feature of employing the incendiary petroleum oils; and though they, as a class, reduce the danger of its presence to a minimum, by confining the material

in a strong metallic vessel, and by locating this at some distance from the buildings to be lighted, the danger from disarrangement or carelessness is but incompletely guarded against, as has already been pointed out, and the personal risk involved in the execution of the routine of attention, which they demand, remains unprovided for.

In the foregoing pages, the entire unfitness of the light petroleum oils has been urged, under whatever name, or with any form of lamp or machine, as household illuminating or heating agents, from the belief that under no circumstances can these substances be so employed without great risk: with the least objectionable modes of their application, namely, in the carburetter and the gas machine, the writer was, until lately, of the opinion that they might, with the exercise of well-defined precautions, be used with a reasonable degree of safety; but a thorough examination, with the knowledge gathered from a more extended acquaintance with the statistics of the subject, have prompted a revocation of that opinion and this expression of it.

There is no field, at present, in which invention would prove of such eminent service to the community at large, as in that of devising methods by which these oils would be utilized upon a vast scale, and thus effect their withdrawal from those applications in which their dangerous qualities are so prominently involved, to the constant peril of life and property. That this object will ultimately be accomplished there can be no doubt. Already, large quantities of these materials are exported, to be converted into permanent illuminating gas, by a process analogous to that employed in our gas-works, the retort and its setting being modified to suit the purpose. Their utilization in other departments of the industrial arts is gradually extending, and it is sincerely to be wished that the time may be not far distant when the demand for them in these legitimate fields of employment may be more than sufficient to meet the supply. As an indication that progress is being made in this direction, this report, which has grown into far more considerable proportions than was originally intended, may be appropriately concluded by a description of the most recent of all the plans for illumination, and in which the light petroleums are called upon to do good and proper service.

The plan consists of three distinct steps: First, the continuous production of hydrogen gas; second, the passage of the hydrogen through a well of the light oils; and third and most important, the conversion of the vapor-laden hydrogen into a permanent gas.

The first step in this ingenious invention consists in leading steam into a furnace charged with coke and heated to redness, by which pro-

cess hydrogen and carbonic oxide are formed. From this mixture the carbonic oxide is removed by passing the gases through cylinders of hydrated lime heated to redness. The result of this treatment is the formation of a fresh equivalent of hydrogen, and the conversion of the carbonic oxide into carbonic acid by union with the oxygen of the decomposed water of hydration. The carbonic acid is removed from the hydrogen by passing through more lime, and the hydrogen is passed onward into another chamber, where it comes into intimate contact with a body of light petroleum oil. Here it loads itself with the oil-vapor, and continues on its course, passing next through tubes heated to a low, red heat, whereby a permanent coal-gas is formed precisely analogous in all its properties to the ordinary coal-gas, though superior to the last (as ordinarily furnished the public) in illuminating quality.

A process which would secure to those living remote from cities, and who are necessarily deprived of the luxury of coal-gas, some substitute for the petroleum gas machine, which shall equal it in the quality of its illuminant, but at the same time shall be free from its objectionable features, would be a more direct means of effecting this much-to-be-desired result, though it affords a problem far more difficult of solution.

In the report herewith submitted to you, it has been my constant effort to present for your consideration, the facts at my disposal freed from any bias.

In the city of Baltimore, during the past year, 69 fires were caused by petroleum and its products. During the same period, in the city of New York, there were 203 from the same cause; while in your own city, no less than 59, or more than from any other single cause, are officially announced to have occurred.

Many of these disasters were accompanied with considerable pecuniary loss, and not a few with deplorable loss of life or injury of person; and I need hardly remind you that the memorable calamity at Chicago, which has become historical from its appalling magnitude, is popularly ascribed to a similar cause.

Suitable laws respecting the sale and employment of these substances, rigidly enforced, might have averted the greater number of these misfortunes.

It is for you, gentlemen of the committee, to present your convictions upon this subject so forcibly as to leave no ambiguity in the public mind as to your meaning; and thus, by the authority which any recommendation from you must carry with it, to pave the way for that stringent legislation upon this matter which is so urgently needed.

If the matter herewith presented for your consideration proves of any service in adding force to such an expression from you, I shall regard my labor as not having been altogether in vain.

Very respectfully, yours, WILLIAM H. WAHL.

To Messrs. J. B. Burleigh, Ch'n, Frederick Fraley, Henry Cartwright, Chas. S. Close, Dr. George A. Kœnig, Dr. T. R. Wolf, Committee.

Franklin Institute.

Proceedings of the Stated Meeting, January 15, 1873.

The meeting came to order at the usual hour, with the President, Mr. Coleman Sellers, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that, at the stated meeting held January 8th, 1873, the following donations to the Library had been received, viz.:

Transactions of the American Society of Civil Engineers for 1871–72. From the Society.

Account of the Operations of the Great Trigonometrical Survey of India, Vol. I. From the Director of the Survey.

Quarterly Weather Report of the Meteorological Office, London, from January to March, 1872. From the Meteorological Office.

Memoirs of the Historical Society of Pennsylvania, Vol. X; with a Catalogue of the Paintings and other Objects of Interest belonging to the Society. From the Society.

Proceedings of the Philosophical Society of Glasgow, Vol. VIII, for 1871–72. From the Society.

Twentieth Annual Report to the Council of the City of Manchester on the Working of the Free Public Libraries; with Catalogues of the Libraries. From the City of Manchester.

The President next presented his annual report for the year just passed, in which the operations of the various branches of the Institute were reviewed. The report dwelt particularly upon the continually improving prospects of the Journal, and the enlarged capacity and usefulness of the Drawing School. The reasons for the postponement of the expected Exhibition were reviewed by the President, and the adverse decision of the Committee having the project in charge was approved. The report was accepted.

The Actuary next reported the minutes of the several Standing Committees.

The report of the Meteorological Section of the Institute was next presented, by Mr. Hector Orr, and showed that during the past year regular meetings had been held, and several papers of practical and scientific interest had been read before the Section.

The report of the Optical Section it was stated would be presented at the following meeting.

The Judges of the Election next announced the result of the election for officers for 1873 to be as follows:

For President, Coleman Sellers.
" *Vice-President*, Henry J. Morris.
" *Treasurer*, Frederick Fraley.
" *Secretary*, William H. Wahl.

To serve as Managers of the Institute for three years, William Sellers, J. Vaughan Merrick, B. C. Tighlman, Hector Orr, John H. Cooper, Henry Cartwright, Henry W. Bartol, Theodore Bergner.

For two years, F. B. Miles, J. E. Mitchell.

For Auditor, to serve three years, James H. Cresson.

The President pronounced the above named to be the officers of the Institute for 1873.

The President, in a brief address, acknowledged the compliment of re-election, and added thereto an earnest appeal to the members to enlarge the sphere of usefulness of the Society by aiding in securing large and desirable accessions to the roll of membership during the present year; remarking, in connection with the subject, that this year would complete the first half century of the life of the Institute.

Upon motion, the Committee on Horse-power of Steam-boilers was continued.

The Secretary next read his monthly report upon Novelties in Sciences and the Mechanic Arts.

Under the head of New Business, Mr. J. B. Burleigh moved that a Committee be appointed to investigate the causes of conflagrations, and to devise, if possible, more efficient methods of preventing them, supporting his motion by reference to the numerous and very disastrous occurrences of this nature at Chicago and Boston. The motion was carried.

The President appointed the following gentlemen to serve upon the Committee, viz.: J. B. Burleigh, Chairman; Frederick Fraley, Henry Cartwright, Chas. S. Close, and Dr. George A. Kœnig.

Upon motion, the meeting was then adjourned.

W. H. Wahl, *Secretary.*

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1. Any resident of North America, or of the West India Islands, may be a competitor for the premium; the southern boundary of Mexico being considered as the southern limit of North America.

2. Each competitor must transmit to the Secretary of the Franklin Institute a memoir, describing in detail the apparatus, the mode of experimenting, and the results; and all memoirs received by him before the first day of January one thousand eight hundred and seventy-three, will, as soon as possible after this date, be transmitted to the Committee of Judges.

3. The Board of Managers of the Franklin Institute shall, before the first day of January, one thousand eight hundred and seventy three, select three citizens of the United States, of competent scientific ability, to whom the memoir shall be referred; and the said Judges shall examine the memoirs and report to the Franklin Institute whether, in their opinion, and, if so, which of their memoirs is worthy of the premium. And, on their report, the Franklin Institute shall decide whether the premium shall be awarded as recommended by the Judges.

4. Every memoir shall be anonymous, but shall contain some motto or sign by which it can be recognized and designated, and shall be accompanied by a sealed envelope, endorsed on the outside with same motto or sign, and containing the name and address of the author of the memoir. It shall be the duty of the Secretary of the Franklin Institute to keep these envelopes securely and unopened until the Judges shall have finished their examination; when, should the Judges be of opinion that any one of the memoirs is worthy of the premium, the corresponding envelope shall be opened, and the name of the author communicated to the Institute.

5. Should the Judges think proper, they may require the experiments described in any of the memoirs to be repeated in their presence.

6. The memoirs presented for the premium shall become the property of the Franklin Institute, and shall be published as it may direct.

Contents for April, 1873.

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THE

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OF THE

FRANKLIN INSTITUTE

DEVOTED TO

SCIENCE AND THE MECHANIC ARTS.

EDITED BY

WILLIAM H. WAHL, PH. D.

ASSISTED BY THE COMMITTEE ON PUBLICATIONS.

Vol. XCV.—No. 568.

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Vol. LXV.—MAY, 1873.—No. 5.

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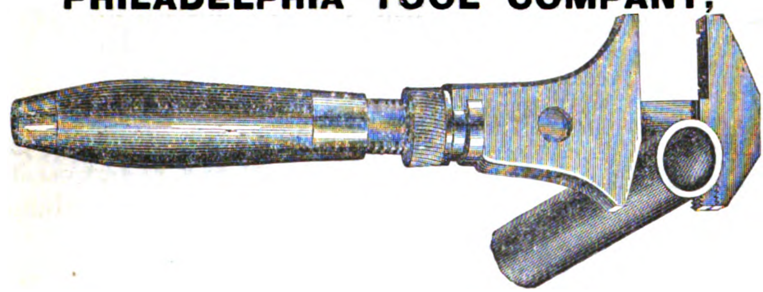

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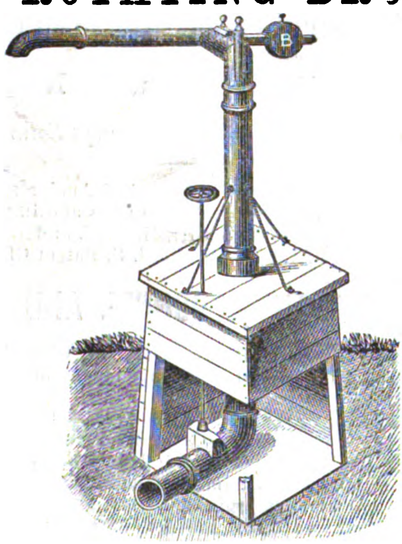

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VOL. LXV.] MAY, 1873. No. 5

EDITORIAL.

ITEMS AND NOVELTIES.

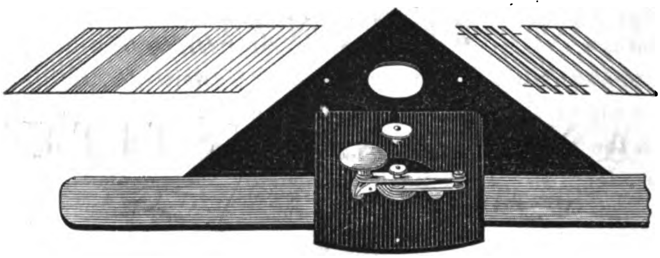
A Section Liner.—We have received from the makers of the instrument (Messrs. J. W. Queen & Co., Philadelphia), the accompanying engraving of a very simple and useful instrument for indicating sections of objects in mechanical and architectural drawings, for drawing screw threads, laying out the spaces of brick-work, and for use in all cases where narrow-spaced parallel lines are needed. The instrument was exhibited some months ago at a meeting of the Franklin Institute, by the inventor, Mr. Theodore Bergner, a member of the Institute. With it a person of moderate ability or practice can produce an effect of uniformity and neatness in sectional drawings almost or quite equal to the engine dividing of engravings.

The accompanying cut gives a perspective view of the instrument, together with a specimen of work executed with it. It consists of a ruler, covered on the under side with rubber cloth, a triangle with a clamping screw passing through near one of its edges, and a plate with the necessary arrangement for producing a movement over equal spaces.

The several parts are placed together as represented in the engraving, there being a little spring beneath the front edge of the top

plate, which presses against one edge of the ruler, while the triangle is clamped against the other edge.

The ruler may be placed upon the paper in any desired position,



the india-rubber cloth underneath keeping it there with perfect security, and it thus acts as a guide for the triangle, which can be moved along over equal steps by alternately pressing down the ivory button and letting it spring back. This movement is produced by the action of a little pawl upon the ruler, which is always to be kept quite sharp, so that it will take a quick and certain hold. The length of the steps taken, i. e., the distance between the lines drawn, is regulated by the screw above the spring, the distance moved over each time being greater as the spring is allowed to have more play. By changing the clamping screw on the triangle, any edge can be placed against the ruler.

The 35-ton Steam Hammer.—There is at present being constructed, for the use of the Royal Gun Factories in Woolwich Arsenal, perhaps the largest steam-hammer ever built. The building for containing this machine will be 150×100 feet.

The unusual size of the proposed machine necessitates a special arrangement for the bed plates. All of these are of a very massive and solid character, and consist in the first place of a hundred 12-inch square limber piles, arranged, at equal distances apart, in the form of a square, 30×30 feet. Around and between the piles, for a depth of 4 feet from the heads, is a bed of concrete. Upon the piles is laid a cast-iron plate, 11 inches thick and weighing 164 tons. This plate is in three parts, and upon it is placed a double layer of 1½-inch oak baulks, the upper layer being placed at right angles to the lower one. Upon these oak baulks comes a second plate of cast-iron, 10 inches thick and weighing 121 tons. This plate is cast in two pieces and covers an area of 27×27 feet. Then comes a 2-ft. thickness of oak timber, consisting of baulks placed with the

grain vertical, or end on, the collection of baulks being held together by an iron strap 6 inches deep by 2 inches thick. These baulks carry a third cast-iron plate, 12 inches thick by 24 feet square and weighing 116 tons. Upon this will come a fourth plate, 12 inches thick by 22 feet square, and weighing 100 tons, a thin packing of oak, just sufficient to prevent contact, being interposed between them.

On the top of the last plate will come another thin oak packing, and then the round anvil block, which weighs 102 tons and is 3 feet 4½ inches deep, 15 feet in diameter at base, tapering to 12 feet at the top.

Upon this yet will come a cylindrical block, not yet cast, 2 feet 8 inches deep and 12 feet in diameter, which will weigh between 60 and 70 tons, and which will carry the movable anvil blocks, which will be of various sizes, to suit the work to be done.

These foundations will be seen, then, to include nearly 700 tons of cast-iron, so disposed as to present the utmost solidity, while at the same time retaining sufficient elasticity to prevent any detrimental consequences arising from the jar of the blows of the hammer, the falling weight of which will be 35 tons.

For the above details we are indebted to our contemporary "Engineering."

Building Stones and Fire.—In a paper upon the fire-withstanding qualities of various building stones, Dr. Adolph Ott, of New York, who has paid much attention to the subject, remarks that, as a class, the limestones are the worst building material of any of the natural stone, inasmuch as they calcine rapidly when exposed to a high temperature, a fact which was abundantly manifested in the memorable calamities which befel Boston and Chicago.

Of the limestones, it is further remarked, the varieties known as dolomite are the poorest, as the presence of magnesia lowers the temperature required to effect the calcination and disintegration of the stone.

Referring to the property of granite, gneiss, mica and other related primitive rocks to crack and explode when exposed to the radiant heat of a neighboring fire, a fact which has also recently received abundant verification, the writer refers the property to the expansive force of the water which all these rocks contain in their fissures.

Of all the natural stones, the author gives the highest place, as regards their heat-withstanding qualities, to the sandstones, which are composed almost entirely of quartz, a material which is only fusi-

ble at an enormously high temperature. The artificial stones, such as Portland and other cements, are also ranked very high for building purposes, their composition—essentially lime and alumina silicate—rendering them quite as capable of withstanding fire as the sandstones.

A Combined Heating and Ventilating Apparatus.—The accompanying engravings illustrate devices of this kind, designed and patented by Mr. Geo. R. Barker, a member of the Institute:

Fig. 1.

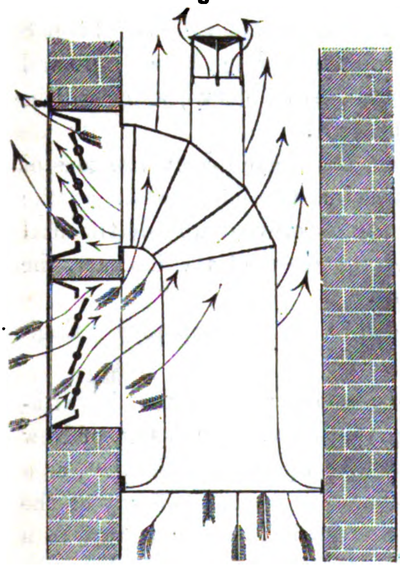
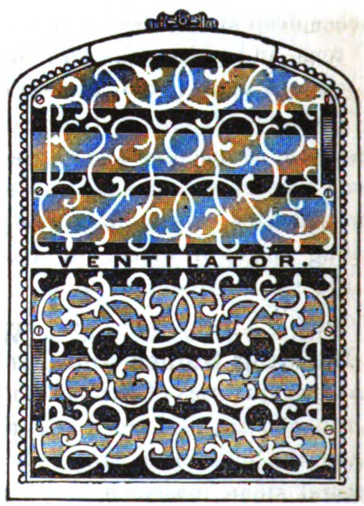


Fig. 2.



The apparatus is placed in a single flue, at the floor of the room to be warmed and ventilated.

The first figure shows a section of the plan. The flue, it will be observed, is supplied with a partition at some little distance below the register opening, through which the heat from the furnace below is to be delivered.

Upon this partition, and communicating directly with the heated air column, is placed a sheet-metal pipe, which terminates in the upper half of the register. Through this the heated air is poured into the room. The lower half of the register is designed for the ventilation; the design being thus to take advantage of the circulation which would be naturally established, and to draw off the somewhat cooled and vitiated air from below.

The second figure is a front view of the register face, showing the lateral division separating the heating and ventilating compartments from each other.

In the upper part of the hot-air pipe there is an adjustable valve secured, which can be operated by means of a handle projecting on the outside of the register-plate of the hot-air opening, whereby either a portion or the whole of the hot air rising in the said pipe can be discharged at any time into the vitiated air flue—the register of the hot-air pipe being either opened or closed accordingly—and thus increasing the warmth and consequently the draft of the vitiated air-flue; a result of great importance in crowded rooms when the heat becomes excessive and the air very impure.

A simple experiment with an ordinary register, especially if it be large, will show that the greater bulk of the heated air which it emits is thrown out from its upper part, while a considerable indraft from the room is constantly entering its lower part.

It was this observation which led to the construction here described. A candle or handkerchief held before the two halves of the combined device indicates clearly the direction of the ingress and egress currents.

Blackwell's Island's Water Supply.—Quite lately the engineers of the Department of Public Works succeeded in solving a problem which has apparently baffled them for years, and established what promises to be a means of permanent supply of water for Blackwell's Island. As long ago as 1850 one or more mains were laid for conveying Croton to the island, but being of small diameter, generally six inches, they were subject to the action of the frost, and also liable to be detached and carried away by vessels catching their anchors under them. In this way the sections were repeatedly detached and had to be renewed sometimes once or twice in a single season. During the winter the temperature of the water in the river very often sank to 30 degrees Fahrenheit, and the motion of the current also abstracted the heat from the pipe, which was of iron, to such an extent that if the water inside was not kept running it almost immediately froze, which it repeatedly did. To obviate this, at one time gutta percha pipes were substituted, but these, in addition to being more easily broken by the anchors of vessels, were continually being worn through by the current rubbing them against the rock bottom of the river. So repeatedly were the pipes, whether of iron or gutta percha, rendered useless in some way or other, that, although there were two

mains, one at Sixty-first street and another at Seventy-ninth (at one time there was one at Seventieth street), the island was continually left dependent upon the two weeks' supply in its reservoir, and sometimes water had to be carried over in boats. The main recently laid consisted of an iron pipe, six inches in diameter, encased in a box, formed of heavy timber, twenty-two inches square. The planks were firmly welded and riveted together, the intervening space being filled in with closely packed cement, and the whole forming a single continuous mass nearly 1300 feet in length. When lying along Sixty-second street, in process of formation, it extended nearly to Second avenue. The total weight was about 200 tons. The river at this point is 1140 feet wide and nearly 100 feet deep, while the current moves at least six miles an hour, so that the safe landing of this enormous mass was quite a triumph of engineering skill. The means used were a dredge-boat of 100 horse-power, worked along a wire cable one inch and a half in diameter, and two powerful tug-boats. Under the main, at intervals of every seventy-five feet, were launching ways, and human power was distributed all along the line. In case of the breaking of the cable, ropes were ready at hand to be used with the tugs alone. A successful start was made, and by ten o'clock nearly 100 yards of the mass was projected into the river. Then the strain on the cable proved so great that a wait was made for slack-tide, which was about four o'clock. From that time forward the work was rapidly pushed, and did not cease till the end of the main was securely rested on a stone abutment waiting to receive it on the island. Water was let in soon afterwards, but turned off as soon as it was perceived that the experiment was a success.

Chemistry of the Bessemer Process.—The conclusions reached by Kessler in regard to the theory of the Bessemer process may possess some interest to our metallurgical readers, since they differ somewhat from the views generally advocated.

The observer in question finds that in the Bessemer process of steel-making the entire amount of carbon present at first is relatively increased, owing to the more energetic oxidation of certain other substances in the iron in the earlier portions of the "blow," and that the carbon first begins to oxidize after the major portion of the silicon has disappeared.

Concerning phosphorus—the most obstinate impurity—Kessler declares that its amount is decreased during the middle portion of the

process, but that its proportion is relatively increased both at the commencement of the "blow," owing to the more energetic oxidation of the other impurities, and towards the end of the operation, when it is, to some extent at least, taken up again from the slag. Sulphur decreases rapidly at first, but increases again in the middle stage, up to the addition of the spiegel-eisen, for the reason that a portion of it, which in the first stage went into the slag, is afterwards taken up again by the iron. When the spiegel-eisen is added and the "blow" recommenced, the sulphur again diminishes, and the suggestion is made that if it were possible to remove the first slag, which contains much of the sulphurous impurities, it would be possible to use brands of iron which are known to contain sulphur for making Bessemer steel.

Rubber Tubes and Coal-Gas.—It has lately been observed that the illuminating power of coal-gas was considerably affected by the passage of the gas through rubber tubing before combustion. For this observation we are indebted to M. Zulkowsky, who has made a series of photometric experiments to determine the amount of this deterioration.

The following series of experiments are tabulated by the author:

Illuminating Power of Gas.

	Estimated direct.	After passing through rubber tubing.	Estimated direct.	After passing through rubber tubing.	Estimated direct.
1st Series,	13·2	10·7	12·9		
2d Series,	12·2	9·2	12·1		
3d Series,		7·8	11·2	7·5	11·3
4th Series,		9·8	11·6	9·9	12·

The diminution in the intensity of the light was so marked after the gas had been passed through rubber tubing of 4½ yards in length that it could be perceived without the help of a photometer; so perceptible, indeed, that the author deemed it to prove beyond question the fact that a positive absorption of some of the light-giving constituents of the gas takes place under these circumstances.

To ascertain which of the ingredients of the gas were thus effected the author carefully dried and weighed several pieces of black tubing and passed a stream of carefully dried gas through them for 62 hours, and found that at the end of that time the tubing had increased in weight 8·64 per cent. The tubing was subsequently placed beneath

the air-pump with sulphuric acid, when the gaseous ingredients were again evolved, the sulphuric acid indicating by its blackening that it had absorbed at least some of that which had thus been liberated from the tubing.

Further observation proved that about 1·1 per cent. of the total volume of the gas was absorbed by the tubing, and the author holds it to be proven that only the heavy hydro-carbons and vapor ingredients of the gas are so absorbed.

In future investigation with coal-gas, the behavior of rubber tubing in this respect must be carefully taken into account.

More Tin Discoveries.—The technical journals have of late years contained every now and then accounts of wonderful tin discoveries in our Western country, all of which however shortly proved either to be entirely unfounded or greatly exaggerated. The last statement of this kind comes to us in the form of the declaration that tin deposits of great richness have been discovered on the north shore of Lake Superior. These discoveries seem to possess the quality of genuineness, inasmuch as their reality has been vouched for by several excellent witnesses. The region in which the deposits have been found is situated in the Province of Ontario, about midway between the Sault Ste. Marie Canal and Thunder Bay. A number of explorations, it is said, were conducted in this wild and uninhabited region after the first announcement of the find of tin, and with the result of finding quite a number of veins of the ore.

As regards the abundance of the ore, or the precise geological character of the locality, no precise data are given. The extent of the region, as far as explored, is stated to be some twelve miles in a southeasterly direction along the lake shore.

The ores, which are said to have been analyzed by Drs. Torrey and Jennings and Prof. Williams, are described by those gentlemen as quite rich and remarkably free from injurious impurities.

The account of these discoveries bears such an aspect of genuineness that, unless great exaggeration has been perpetrated by the local explorers, the region will soon attract the attention of capitalists.

During the coming summer the localities will probably be explored by competent observers, when the true extent and value of the reputed discoveries will be brought to light. Should the first accounts prove in no way exaggerated, the fears of those who are troubled concerning the probable scarcity in the supply of this invaluable metal, in

view of the great draws upon the deposits of Cornwall and Banca, may be quieted, especially since to the new region, then, we may safely add that of Queensland, an account of which was published in one of the late issues of the "Journal."

Glycerin as a Solvent.—M. Klever has published a lengthy table of the solubility of various substances in glycerin, the following abstract of which may be of value to some readers of the "Journal." From his published observations it appears that one hundred parts, by weight, of glycerin dissolve, at ordinary temperatures:

Parts by Weight.	Substance.	Parts by Weight.	Substance.
20	Arsenious Acid.	0·20	Phosphorus.
20	Arsenic Acid.	20	Plumbic Acetate.
10	Benzoic Acid.	50	Potassium Arsenate.
10	Boric Acid.	3·50	" Chlorate.
15	Oxalic Acid.	25	" Bromide.
50	Tannic Acid.	32	" Cyanide.
40	Alums.	40	" Iodide.
20	Ammonium Carbonate.	8	Acid Sodium Carbonate.
20	" Chloride.	60	Borax.
5·50	Tartar Emetic.	98	Sodium Carbonate.
10	Barium Chloride.	20	" Chlorate.
30	Cupric Sulphate.	0·10	Sulphur.
7·50	Mercuric Chloride.	50	Zinc Chloride.
27	" Cyanide.	35	Zinc Sulphate.
1·9	Iodine.	50	Urea.

Parts by Weight.	Substance.
0·45	Morphine.
0·50	Quinine.
0·25	Strychnine.

Portable Ink.—From the "Journal of the Society of Arts" we learn that Prof. Bœttger has suggested an idea that may prove of service to exploring parties and others. White blotting-paper is saturated with anilin black, and several sheets are pasted together to form a thin pad. When wanted for use, a small piece is torn off and covered with a little water. The black liquid which dissolves out is a good writing-ink. A square inch of the paper will be found to perform considerable service, and, as water is always available, the ink is readily made.

Quantitative Spectroscopic Analysis.—The especial merit of the spectroscope has heretofore been regarded to be the determination of the presence of certain elements in a luminous body, when there in such minute traces as to altogether defy detection by other known methods of analysis. The idea of extending the indications of this method of analysis to the estimation of quantitative values has often been suggested, but the difficulties to be overcome are very great.

Quite recently the subject has received considerable attention in learned circles, in consequence of a communication to the French Academy by M. Janssen, the eminent spectrescopist, who has pointed out very clearly, in a memoir to that society, the principles upon which such an application of the spectroscope might be based.

Mr. Janssen indicates two independent methods of procedure in such investigations, which may be employed simultaneously, and so serve as a species of control upon results obtained.

One of these methods is to measure the intensity of the bright lines afforded by a substance in the spectrum; the other is the measurement of the time required for the complete volatilization of a substance in the flame.

It is said that an apparatus constructed to take advantage of the first-named method has been successfully employed to determine the quantity of certain elements in the ashes of plants.

Should further experiment verify the expectation here expressed, the practical value of the spectroscope, which has already achieved wonders, will be greatly enhanced.

The East River Bridge.—From private sources we learn that work upon the bridge is progressing rapidly. The first anchor-plate was cast, two weeks since, very successfully. Anchorage excavation will be completed in about two weeks. The first set of anchor bars, making at Phœnixville, are about ready for testing. Masonry gangs all at work on piers.

The Signal Service Bureau.—It is stated that the "bureau" is about to extend its already elaborate system of weather prophecies, so that the valuable and exact information which is now daily distributed about the country through the agency of the press, may be made accessible to those who are not so fortunately located as to be able to avail themselves of morning and evening papers.

To effect this extension of its usefulness, the "bureau" proposes

to avail itself of the rural post-offices as mediums for the distribution of weather intelligence. The territory east of the Mississippi has been divided into districts of about two hundred miles in extent in every direction, each having near its centre a telegraph office, to which the weather intelligence will be each day telegraphed from Washington. Immediately on receipt of this intelligence, copies of the same will be sent to all the post-offices within the district which can be reached by post as early as 6 o'clock P.M. These weather maps will then be posted up on bulletin-boards, and may be consulted by the farmers and others interested, who may thus be guided in their business affairs. The arrangement here proposed will doubtless contribute greatly to the efficiency of the "bureau."

Self-Lighting Signal Lantern.—Some experiments with the Holmes lamp have recently been published. This lamp depends for its efficiency upon the fact that the phosphuret of calcium, in contact with water, develops spontaneously combustible phosphuretted hydrogen gas. The experiments in question, which are stated to have turned out very satisfactorily, are as follows: A long tin tube, firmly closed, in which was contained 900 grains of the phosphuret of calcium, was kept afloat upon the water by being fastened to a piece of board. Before putting it in the water, the bottom of the tube was perforated to allow the water to enter, and the upper point cut off, so that on the entrance of the water the self-lighting phosphuretted hydrogen gas was developed.

A flame four or six inches broad and twenty-four inches high, lighted up the steamboat and pilot boat, which had gone out four miles on the sea, with a party to witness the experiments, so brilliantly that the vessels and the men upon them are stated to have been distinctly visible from the lighthouse at that distance.

The Planet between Mercury and the Sun.—The existence of an intra-mercurial planet has been frequently argued for upon astronomical grounds, though an objective proof of its presence has as yet not been forthcoming. Mr. Cowie, however, has lately telegraphed from Shanghai an account of a recent observation in which he assumes that a black spot seen on the sun's disk at 9 A. M., on March 24th, marked in reality the transit of the supposed planet. It must, however, be added that both the observation and the inference drawn therefrom need corroboration.

* Boston Journ. of Chem., April, 1873.

The Oxyhydrogen Light.—The concluding portion of M. Blanc's report upon the practical application of the light of M. Tessié du Mothay in Paris, contains the following interesting resumé:

The oxygen gas supplied for the purpose by the company, though never containing less than 13 to 14 per cent. of nitrogen, is believed to be as pure as can be expected when manufactured on so large a scale and for such a purpose. Sufficient time, it is stated, had not elapsed to show conclusively whether the manganate process of obtaining oxygen was as continuous as was claimed. With regard to the price of the oxygen, the same uncertainty exists in the mind of the critic. The light, the report continues, would, in its application to the public streets, encounter too many disturbing causes to render it reliable. For private purposes, however, the objections are not so great, as a carburizer and regulator can be more readily applied than to the street lamps.

For private purposes the oxyhydrogen light will require to each house special burners, a double set of pipes, two meters, two regulators, and a well-appointed carburizer, arrangements requiring an outlay of money and an amount of trouble too great to be deemed desirable.

The assertion that, with oxygen, the combustion is complete is incorrect. For complete combustion more oxygen than usual is required, and to obtain it much of the illuminating power of the gas is lost. The experiment in the boulevards have shown that for the illumination of streets the oxyhdrogen light is not economical, though, in a hygienic point of view, it may be far superior to the present modes of illumination.

Electrical Conductivity Affected by Light.—A most curious experiment, involving an alteration in the electrical conductivity of the element selenium, an element of very high resistance, has recently been published by Mr. Willoughby Smith. Mr. Smith took several bars of this substance of from 5 to 10 c. m. in length, and 1 to 1½ mm. in diameter. Each bar was hermetically sealed in a glass tube, and had a platinum wire at each end for the purpose of connection. It was found that the resistance altered materially, according to the intensity of the light to which the element was subjected. When the bars were fixed in a box with a sealed cover, so as to exclude all light, their resistance was at a maximum, and remained very constant; but immediately the cover was removed, the conductivity increased

from 15 to 100 per cent., according to the intensity of the light falling upon the box. The mere interception of the light, by passing the hand before an ordinary gas burner placed several feet from the bar, increased the resistance 15 to 20 per cent. When the light was intercepted by glass of various colors the resistance varied according to the amount of light passed through.

To insure that temperature had nothing to do with the results obtained, one of the bars was placed in a trough of water so that there should be about an inch of liquid for the light to pass through. The results under these conditions were the same. And again, when a strong light, from the ignition of a narrow band of magnesium, was held about 9 inches above the sealed tube, the resistance immediately fell more than two-thirds, returning to its normal condition, immediately the light was extinguished.

Asbestos.—The attempt which has recently been made, with some prospect of ultimate success, of incorporating asbestos into textile fabrics, by mixing the fibres of this substance with the cotton or wool during the weaving process, has attracted some attention to the localities where suitable deposits are known to exist. The material is by no means rare, since it is most generally present in greater or less quantity in regions where the so-called primitive formations are found. But while its employment, for several fire proofing compositions, tolerably well known to the manufacturing public, does not demand an article of unusually fine character, it appears that for its incorporation into textile fabrics only those qualities with the finest and longest fibres are suitable.

There are extensive deposits of this material within the limits of the United States; that found in the eastern slope of the Green Mountains and in the Adirondack region being of the best quality thus far discovered, for fineness and tensile strength. Recent discoveries, however, in North Carolina, may, when better known, carry the attention of those interested in the material to that region—it being asserted that deposits of unequalled quality exist in that State.

The fibre of the New York and Vermont asbestos varies in length from two to forty inches, and the material resembles unbleached flax when found near the surface, but when obtained from greater depths it is pure white and very flexible. In Europe, the material is found in considerable quantities in the Tyrol, in Hungary, Corsica and Wales.

The industrial applications of asbestos are steadily growing, and it bids fair to become, for certain purposes where its fire-withstanding qualities and its considerable tensile strength are prominently involved, an indispensible article, on which account the discovery of deposits of suitable quality may be regarded as of importance.

Ammonia for Mercury Vapors.—The fact that workmen exposed to the vapors of mercury for any considerable time seriously imperilled their health has long been well known, and various suggestions have, from time to time, been made to neutralize this danger in the industries largely employing this substance.

The last suggestion, which was made to the French Academy, consists in the free use of ammonia, which, it is stated, has been employed with success for several years by M. Meyer, in the mirror factory at Chauny. During the time that mercury has been employed, that is since 1858, no workman has been attacked by the mercury, while those men who were subject to the attacks of the disease have since suffered more rarely and less severely. The ammonia, it is recommended, should be thrown around the shops in the evening rather than in the morning.

FRACTURE OF CAST-IRON PIER CYLINDERS.

By John C. Trautwine, Civ. Eng.

It is not, perhaps, generally known to the profession that cast-iron cylinders, composed of sections bolted together through inside horizontal flanges and filled with concrete, as is usual when employing them for bridge piers, &c., have, in several instances, in the United States, cracked or split asunder, entirely around their circumference, under the influence of severe cold weather. The reason of this, I presume, is that the outer and more exposed cylinder tends to contract to a greater degree than the inside and more sheltered concrete, and that the hold which the inside flanges have upon the solidified concrete in which they are imbedded prevents the contraction from taking place without rupture of the cylinder. Unless suitable means be applied to prevent this, the efficiency of such cylinders may be much impaired. It has been suggested that an inside lining of vertical wooden staves, projecting inwards as far as the flanges do, will be an effective remedy. Other methods will no doubt present themselves. My object is merely to give greater publicity to an important fact.

NOTE ON THE PRODUCTION OF AMMONIA IN NITRIC ACID BATTERIES.

By W. Levison.

I first noticed the production of ammonia in a nitric acid battery while using a simple combination of the kind in the month of January, 1869, and on the 23d of that month I showed the phenomenon to Mr. Charles Pearce, at Cambridge. It was, however, observed under circumstances that led to its being for a long time considered due to a merely local action of the dissolving zinc upon nitric acid which had diffused through the porous cup, but recent experiments show, to my mind, that the ammonia produced in nitric acid batteries results from a reaction between the electrolytically liberated hydrogen and the nitrogen of the nitric acid in the inner cup.

As no discussion of the theory of the battery, to the best of my knowledge, takes cognizance of this reaction, I thought it might be new and worthy of attention. I must, however, confine this note to a mere statement of the fact.

January 14*th*, 1873. I put up two small Grove cells, constructed of zinc and platinum. The inner cups were filled with a mixture of

Saturated solution of potassic bichromate, .	5	parts,
Commercial oil of vitriol, . . .	$2\frac{1}{2}$	"
Nitric acid, C. P., ...	1	"

The zincs, newly amalgamated, were put in dilute sulphuric acid. Distilled water only was used. One cup was set in operation, the other left. After 24 hours the liquids in these two batteries were examined for ammonia; the cup set in operation being called Battery A, the other Battery B. In testing the liquids from inner and outer cells of both batteries, ten cubic centimeters of each were separately concentrated to about one-fifth, treated with an excess of caustic soda and the platinum dish covered with a watch-glass having a piece of red litmus paper adherent to its under side.

Battery A. Liquid from inner cup. Paper immediately turned blue. Odor of ammonia strongly perceptible.

Battery A. Liquid from outer cell. Paper became blue in a short time. Odor of ammonia very faint. Only a trace present.

Battery B. Liquid from inner cup. Paper faintly changed in ten minutes. No odor of ammonia perceptible.

Battery B. Liquid from outside cup. Same result precisely.

Local action does not produce ammonia in important quantity.

January 26th, 1873. Set up a single cell, Grove form, with dilute sulphuric acid in outside cup, and a mixture of equal parts of saturated solution of potassic nitrate and Kalbfleisch's commercial oil of vitriol in inside cup. Proved in advance each liquid to be free from ammonia.

After 24 hours tested both liquids for ammonia. That from inner cup contained great quantities, but that from outer cup gave no evidence of containing ammonia.

February 1st, 1873. Set up a single cell grove with nitric and dilute sulphuric acid. Immediately after setting up, and before closing circuit, tested both liquids for ammonia. The nitric acid gave no trace of the sulphuric acid; gave a faint ammonia reaction, and yielded a trace of nitric acid, which probably got into it by diffusion through the porous cup. Ten minutes after putting battery in operation, ammonia in large quantity was found in inner cell.

The conversion of nitric acid into ammonia must be taken into consideration in preparing the nitro-chromic battery fluid, as proposed by me in the "Journal of the Franklin Institute," vol. 59, page 376, inasmuch as sufficient nitric acid must be used in excess of the quantity converted into ammonia during the time which elapses before the last molecule of chromic acid is reduced to chromic oxide.

Editorial Correspondence.

QUEBEC, *March 25th*, 1873.

Editor of Journal of Franklin Institute:

DEAR SIR,—I notice in this month's issue of your journal an account of an improved method of bending glass tubes for laboratory purposes.

I have long used a plan which, though probably adopted by many, I have not seen recommended. Instead of heating the tube in the flame of a Bunsen burner, I do so in the luminous flame of an ordinary fish-tail or bat's-wing burner, placing the tube across the flame when I want a sharp bend, but lengthways in the flame when I wish it to be gradual. Of course the tube is blackened, but the carbon can be readily wiped off with a dry cloth when the tube is cool. The diameter of the tube is much less likely to be contracted than when the ordinary method is employed.

Yours, J. DOUGLAS, JR.

Civil and Mechanical Engineering.

GAUGING OF RIVERS.

By Bvt. Brig. Gen. HENRY L. ABBOT, Major of Engineers.

The report upon the Physics and Hydraulics of the Mississippi river was completed during all the hurry and confusion attendant upon the commencement of civil war. Moreover, the scope of the work confined it strictly to the solution of the problems of protection for the low lands of the Mississippi against river floods, and of increased depth at the mouths. For these reasons the discoveries in the laws governing flowing water were merely announced incidentally, in order to establish the exactness of the solutions of problems which presented themselves in the prosecution of the work. As a practical treatise setting forth these discoveries its arrangement is therefore defective; and from the terseness of the language in which the principles are laid down, engineers have fallen into errors in applying them. Cautions once given were not repeated, but were supposed to be borne in mind and observed wherever applicable.

The chapters relating to the laws of flowing water have been translated into French and German, and extensively reviewed in this country and in Europe. The newly discovered laws and formulæ are now employed upon numerous river improvements in charge of officers of the Corps of Engineers. An important work upon hydraulics by MM. Darcy and Bazin, of the Corps des Ponts et Chaussées, published in 1865, has by new experiments and discoveries furnished means of testing and extending the laws laid down in the Hydraulics of the Mississippi. A still later work, published in 1867 by M. Heinr. Grebenau, has furnished additional and valuable data.

For these reasons, I propose to invite attention to such points in the report upon the Mississippi as, having been misapprehended, seem to require more full development; to define precisely the method of applying the new discoveries to the practical gauging of rivers; and, lastly, to test the new formulæ for discharge by all the fresh data furnished in the works of MM. Darcy and Bazin, and M. Grebenau.

Cautions Relating to the Use of River Formulæ.—The subject upon which misapprehensions have been most frequent, is the slope of natural streams. From misunderstanding this matter, the formulæ have

been erroneously applied in two ways—one of which makes them appear to give too large and the other too small mean velocities. A few words will make this subject clear, and define the limits within which it was contemplated that the application of the formulæ should be restricted.

In flowing between two points, A and B, most rivers encounter three distinct resistances to motion, in overcoming which they expend the power due to the fall in water surface between the two points. The first of these resistances is that arising from the adhesion of the water to its bed, and from the cohesion of the different particles to each other; the second resistance is that arising from inequalities of cross section, which give rise to disturbances, eddies and loss of living force; the third resistance is that due to bends, which act in a manner analogous to dams—checking the flow of the water and causing it to rise until it attains sufficient head to regain the lost velocity. The fall in water surface between A and B, which measures the power to overcome these three resistances, may, therefore, be considered to be divided into three parts, each of which overcomes one of the resistances.

Hence, if it were possible to obtain a complete mathematical expression for the flow of the river, it must comprise three formulæ based upon this triple division of the head. Unfortunately this division is impracticable for rivers, for the reason that the inequalities in cross section occasioning the second resistance cannot be determined with sufficient precision. This fact renders inapplicable to rivers the formulæ for "permanent motion" upon which many beautiful theoretical investigations have been made.

We are thus compelled to represent these three resistances by two formulæ. It would, perhaps, be possible to do this in the way which has been vainly attempted heretofore by hydraulic engineers—i. e. to frame one formula based upon the supposition of perfect uniformity of motion in a straight line for the distance between the points A and B—provided we should add a second formula which should measure the effect of the sum of the other two resistances. In other words, a formula with constants deduced from experiments upon smooth artificial canals, would be combined with one deduced to represent the total head consumed in rivers in overcoming the resistances due to variations in section and bends. This plan was not adopted in the investigations upon the Mississippi, as it was believed that better results would be obtained by dividing the effect of the

second resistance between the constants of the formulæ representing the other two. In straight portions of rivers with ordinary slopes, the disturbances arising from variation in section do not materially differ; and a certain kind of approximate uniformity of motion exists, which constants properly deduced from observations on rivers may represent as accurately as others do the perfectly uniform motion of smooth canals and troughs. The principal effect of the second resistance is confined to the vicinity of bends, where the changes in cross sections are the most violent; and this resistance is, therefore, chiefly taken into account by the bend formula; but it must be carefully borne in mind that the portion thus accounted for does *not include the whole.* There is a distinct part of this second resistance which necessarily affects the constants of any formula based upon the supposition of uniform motion and derived from observations upon natural channels. Such formulæ should, therefore, never be applied to water flowing in smooth artificial channels, where perfect uniformity of motion is obtained. This mistaken use has in a few instances been made of our formulæ.

A second and worse error has arisen from using in the formula for the first resistance, the whole fall in water surface between the points A and B, without first subtracting the portion indicated by the bend formula as consumed in overcoming the resistances of the bends and larger irregularities of cross section between the two localities.

The first of these errors of application causes the formulæ to apparently give too small, and the second too large results. A caution against both errors was given in the Report, but, as already stated, it has in some instances been overlooked. It should be distinctly understood that these formulæ are *not applicable to water flowing in smooth artificial channels;* and that, where bends exist in natural channels, their effect in consuming the head of water must be *taken into account by the bend formula and subtracted* before applying the other.

On page 310 Physics and Hydraulics of the Mississippi the applicability of the new formulæ for the discharge of rivers was restricted to cross sections not less than 100 sq. ft. in area, and to slopes not exceeding 0·0008. These limits were adopted, partly because they comprised all the data at hand, and partly because it was foreseen that the width must exert a certain influence not allowed for in the equations when the area of cross section was reduced much below 100 sq. ft. It appears from the new data now available that these limits of application may be considerably extended, especially in respect to the slope.

Practical Gauging of Rivers.—For practically gauging large rivers, the following has been found to be the best plan: A locality is selected in a straight portion where the water flows smoothly and without obstruction. A base line, which should rarely exceed 200 ft. in length, is laid out parallel to the current, and the exact cross section in front of this base is determined by careful sounding. To obtain the discharge, two theodolites are established, and the angular distance from, and time of transit past each end of the base, is noted for *numerous floats well distributed between the banks.* On the Mississippi, to observe 75 floats was found to be a good day's work for a party of two engineers and eight boatmen with two boats; the maximum day's work was to observe 120 floats.

The floats should be made double; the surface float being a minute tin ellipsoid, a piece of cork, or some other small light body bearing a little flag. The lower float may be a large box or keg without top or bottom, kept upright by a lead ballasting;—or, better yet because lighter, two sheets of tin bent at right angles aud soldered together at the bend so as to make all the angles between the four fans right angles. Annoyance was experienced on the bar of the South West Pass from fishes seizing this latter description of float. The essential conditions are that the lower float shall so greatly preponderate in area over the upper, and shall be connected by so fine a wire or cord, that its rate of movement shall govern the whole combination.

The centre of the lower float should be placed at the *mid depth of the stream,* in each vertical plane of transit; because the rate of movement will then be unaffected by wind whether blowing strongly or gently, up stream or down stream. This very important fact was discovered during the investigations upon the Mississippi, and a knowledge of it greatly conduces to accuracy and facility in gauging rivers. It is sometimes a little troublesome to adjust to mid-depth in the different planes of transit; but with a tolerably uniform and symmetrical cross section, the average mid-depth of the river may be adopted for all the floats without sensible error. If floats passing near the surface or the bottom are used, errors in the computed discharge exceeding four per cent. may be caused by an ordinary breeze; and as these errors are positive or negative according to the direction of the wind, discrepancies of nearly ten per cent. may result in the measurements on different days, when there is no real variation in discharge. All this uncertainty is avoided by using mid-depth floats. The explanation of this fact is found in the oscillation of the axis

(horizontal) of the vertical parabola indicating the law of change in velocity from surface to bottom, under the influence of wind. The mean of this curve remains the same for a given discharge, and the curve in every position of its axis crosses the same mid-depth point; hence the ratio in question is constant, but no other is so. This continual oscillation explains many of the discrepancies which annoy observers in measuring sub-surface velocity.

The exact level of the water surface on a permanent gauge rod, should be carefully noted when the observations begin and terminate.

The following is the method of plotting the results thus obtained and deducing the discharge per second:

Upon a sheet of section paper, the base line and the two perpendiculars across which the times of transit were noted, are laid down. From the recorded angles and a table of natural tangents, the distances from the base line to the points at which each float passed both lines are plotted. These points being connected by twos, indicate the paths of the floats. Upon each path the seconds of transit—i. e. the difference between the two recorded times of transit—is written. These seconds of transit are next examined, and the total width of the river is marked off into as many "divisions" as it seems proper to assume are traversed by water moving with sensibly unvarying velocity. On the Mississippi the width of these "divisions" was uniformly assumed at 200 ft.—the total width being about 2600 ft. A mean of the seconds of transit of all the floats in each "division" is next taken, and, when reduced to velocity in feet per second, is adopted as the mid-depth velocity in that "division."

A mean of all these mean mid-depth velocities—interpolations being made if any are missing—closely approximates to the mean velocity of the river, provided the "divisions" are equal in width. This method of deducing the mean velocity from the mean mid-depth "division" velocities, involves two errors which nearly balance each other—viz., the inequality in area of the "divisions," and the difference between the mid-depth and the mean velocity in any vertical plane. The correction ratios for these errors are respectively about 0·93 and 0·98 in large rivers—giving a resulting mean velocity $\frac{0{\cdot}93}{0{\cdot}98} = 0{\cdot}95$ times the true value. The ratio 0·98 varies for natural channels between the limits 0·92 for a depth and mean velocity of 1 ft. and 0·99 for a depth of 80 ft. and mean velocity of 8 ft. per second. Its law

of variation is given in detail on page 293 Physics and Hydraulics of the Mississippi. The ratio 0·93 is nearly constant for ordinary river channels; its law of variation is unknown.

If a very exact computation is required—as for instance in testing the constants of a formula—the "divisions" are laid down on the plot of the cross section of the river, and the area of each is computed for the stand when the velocity observations were made. The different "division" mid-depth velocities—including interpolations, if any are wanting—are then substituted successively for $V_{\frac{1}{2}D}$ in the expression $V_{\frac{1}{2}D} - \frac{1}{12}\sqrt{b\,v}$ in which v is the mean velocity of the river, D the mean depth of the division, and $b = \frac{1{\cdot}69}{\sqrt{1{\cdot}5+D}}$; each result is multiplied by the corresponding area of cross section; and finally the sum of these products is placed equal to the products of v by the total area of cross section. The resulting equation contains v, $\sqrt{v}$ and known terms, and hence may be readily solved. The lesser root is the true mean velocity of the river. This method of computation gives the most accurate determination possible of the discharge of a large river. It is analogous to the plan adopted for the Mississippi, but is a slight improvement, because the peculiar properties of the mid-depth velocity were not discovered in time for use upon that survey.

A mean velocity intermediate in accuracy to those given by the two methods just described, may be computed by substituting the grand mean of the different mean "division" velocities—including interpolated velocities if any are missing—for $U_{\frac{1}{2}r}$ in the following equation, in which the value of b is that given above, D being replaced by r the quotient of a, the area of cross section, divided by p, the wetted perimeter, both in feet. The method is simple, and quite exact for ordinary river sections, but should not be applied to a rectangular section.

$$v = \left(\left[1{\cdot}08\ U_{\frac{1}{2}r} + 0{\cdot}002\ b\right]^{\frac{1}{2}} - 0{\cdot}045\sqrt{b}\right)^2$$

The theory of these different methods of computing v, is explained pp. 295–296 Physics and Hydraulics of the Mississippi.

Such operations and computations as those just detailed are laborious and expensive, but are essential to the accurate gauging of a river. To determine the discharge of the Mississipi at permanent stations, cost nearly $20 per diem, before the war. At present prices,

it would cost at least $30. For these reasons, engineers desirous of ascertaining the amount of water which a given river is discharging, have been accustomed to construct a table from a set of single measurements of the amount passing at different stands of the river between high and low water; and then to deduce the discharge on any desired date, by noting the stand of the river and adopting the corresponding volume indicated by the table. This method gives results worthy of no confidence. The discharge at any given level of water surface varies enormously for different freshets, and even in the same freshet is quite different when the river is rising from what it is when falling. Near the mouth of the Ohio, when the Mississippi was about 10 feet below high water and rising most rapidly, its discharge was 1,200,000, and when falling most rapidly at this same level was 800,000 cubic feet per second—a difference of one-third! From a series of careful measurements continued daily for a river year, a table of mean discharges for each foot of the gauge rod between low and high water, may be constructed, by means of which the total annual discharge in any subsequent year may be deduced from recorded gauge readings; but such a table will furnish no means for deducing the discharge on any *given day*. It is at best a rough method and suited only for general investigations.

A knowledge of the discharge of a river both in long periods and on single dates is often necessary to the hydraulic engineer, in order to enable him to decide upon practical projects connected with its navigation, its overflows or its water power. Some economical and simple method of gauging is, therefore, a necessity; and various formulæ have been proposed to replace the costly operation of actual measurement. These formulæ were all tested carefully during the investigations upon the Mississippi; and none gave results indicating the requisite accuracy. New formulæ were framed whose precision it is confidently believed may be depended upon for practical use. Some of the grounds for this belief will soon be given, but here the point will be assumed, and the method of using them detailed. The variables which enter these formulæ require a knowledge of the mean cross section and a map of the channel between two points of the water surface, A and B, whose difference of level is exactly known. Whenever practicable, A and B should be located on a straight and regular portion of the river, the effect of bends being thus eliminated.

As this is not always possible, owing to the very gentle slope in water surface of most natural streams and especially of large rivers,

the general case will be considered, and bends be assumed to exist between A and B.

The field operations will consist in making a survey of the channel, including numerous soundings, between two permanent bench marks placed near the water at the points A and B; and in running a line of levels with the most extreme accuracy between these benches, so as to fix their relative level within a small fraction of an inch. When practicable, both banks should be occupied. These points, A and B, must be located with care as far apart as practicable, and distant from any eddy, and be placed where the current on the bank flows with *equal velocity*. The latter condition is necessary because water in motion exerts less pressure than when at rest; and if it moved rapidly past one bench and was nearly stationary at the other, a difference of level which has nothing to do with the motive power of the stream, would vitiate the observation. This matter cannot be overlooked. Baumgarten actually measured a difference of level in water surface amounting to 0·4 of a foot, between the middle of the Garonne and its right bank, where the river was only 600 feet wide and nearly straight. The corresponding difference in velocity did not probably exceed three or four feet.

In determining the mean dimensions of cross section, care must be taken to extend the soundings throughout the entire distance between the benches, A and B. Errors have often been made from forgetting that the measured fall in water surface between two stations, corresponds to the *mean channel between them*, and not to that at a short intermediate base for velocity observations. The water level, when the soundings are taken, must of course be referred accurately to the bench marks, in order to determine the area corresponding to any subsequent stand of the river.

These surveys completed, a frequent gauging of the river can be made at trifling expense. For this purpose, it is only necessary, at any desired date, to refer the water surface at A and B to the bench marks by accurate levels, and thus to determine the fall and corresponding cross section of the river—from which the discharge may be computed. Of course, it will be desirable to make a few actual measurements in order to test the applicability of the formulæ to the peculiar conditions of the river bed in question; and, if needful, to deduce a correction.

Two precautions must not be neglected in measuring the fall in water surface. The observations must be *simultaneous*, in order to

avoid the effect of any oscillation in the river, and *calm days* must be selected. The latter precaution is necessary, not only because waves render it difficult to determine exactly the level of the water surface, but also because important changes of level result from the general piling up or lowering of the water under the influence of winds. Hurricanes have raised the level of the Gulf of Mexico seven feet at the mouths of the Mississippi, and prevailing winds often produce two feet difference in that level.

The computations from such data are simple. A line following the mid-channel on the map, is drawn, composed of straight lines with angular changes, wherever necessary, of 30°. A mean velocity is next assumed (to be corrected subsequently if required) and the value of h is computed in the following formula, in which N represents the number of the deflections:

$$h = \frac{v^2 \, \mathrm{N} \sin^2 30°}{134}$$

The deduced value of h is next subtracted from the total fall in water surface observed between A and B; and the remainder, divided by the distance in feet between these stations measured on the middle line of the river, is the true value of s in the following formula for the mean velocity. The numerical values of the other variables, expressed in feet, are taken from the mean cross section. The discharge of the river in cubic feet per second is the product of this mean area by the value of v resulting from the computation. If any material error has been made in assuming v in the bend formula, the work must be repeated until the requisite approximation has been made. W is the width; the other quantities have been already defined. A table to facilitate the use of this formula is appended to this paper.

$$v = \left(\sqrt{0{\cdot}0081\, b + \left(\frac{225\, a \sqrt{s}}{p + \mathrm{W}}\right)^{\frac{1}{2}}} \; 0{\cdot}09 \sqrt{b}\right)^2$$

The following formulæ give the value of each variable in this equation in terms of the others and known quantities. z is equal to $0{\cdot}93\, v + 0{\cdot}167 \sqrt{b\, v}$; and when p is not known by measurement it may be assumed to be $1{\cdot}015$ W.

$$s = \left(\frac{(p + \mathrm{W})\, z^2}{195\, a}\right)^2$$

$$a = \frac{(p + W) z^2}{195 \sqrt{s}}$$

$$p + W = \frac{195 \, a \sqrt{s}}{z^2}$$

(To be continued.)

PENNSYLVANIA RAILROAD SHOPS AT WEST PHILADELPHIA.

By Joseph M. Wilson, C. E.

P. A. Engineer, Construction Department, Pennsylvania Railroad.

(Concluded from Vol. LXIII, page 198.)

Freight Car Repair Shop.—This building is located No. 15 on Plate I, and the elevation and plan are given on Plate XVI. It is 227 feet long by 108 feet 9 inches wide; outside dimensions, the walls being of brick and built according to the same details as previously described for the other buildings. There is only one story, and the roof is nearly flat, being supported by four rows of intermediate timber posts, 8 by 8 inches, and 10 by 10 inches section. The principal rafters are 6 by 8 inches, the braces 5 by 6 inches and the purlins 3 by 7 inches. The arrangement of framing is very simple, and is easily seen by reference to the Plate. It allows of a ventilator of 33 feet span, running the whole length of the building except on the end panels, having large glazed sash hung to swing on centres. The pitch of the roof is 5 degrees, and it is sheeted with tongued and grooved $\frac{7}{8}$ inch sheeting, covered with tarred felt and gravel. There are six large circular doors at each end of the shop, having 11 feet opening, and a corresponding number of tracks run through its whole length, and afford room for forty-two freight cars. The system of flooring is the same as in the other buildings, and work benches are fixed along the walls and between the tracks, with closets attached, for the workmen.

Water Supply.—For some years the supply of water was drawn from the city, but, in consequence of the great and increasing consumption, it was decided to erect private works. A reservoir was built on high ground, at a point marked 18, on Plate I, 60 feet in diameter and 16 feet deep, constructed of stone masonry, lined with brick laid in cement, its capacity being 338,200 gallons. A well was sunk to a gravel bed yielding a large amount of water, at No. 16, on

Plate I, and a steam pump erected. Although furnishing a copious supply, it was not sufficient for the demand, and another well was sunk at No. 17, Plate I, it being the intention to use both wells. The latter, however, furnishing a much larger supply than the former, the use of the old well was abandoned. A pipe was laid connecting the new well with the river, so that in case of necessity river water could be used, but it has not, so far, been needed.

It was desirable to avoid the use of river water if possible, it being so often impure from effects of rain storms and freshets. From experiments made in 1868, the amount of water consumed at the shops, locomotive houses and passenger stations averaged 132,100 gallons in every 24 hours, and since that time it has considerably increased. At the well there is a duplex Worthington steam pump, capable of throwing 20,000 gallons of water per hour, and two connected boilers, each 20 feet long and 30 inches in diameter.

Conclusion.—It is proposed, in conclusion, to make a general review of the different buildings, stating where we think improvements could be effected, and where we have made them in later works of the same kind. In regard to sewers, we are now using terra cotta pipe largely for all except main sewers, say up to 18 inches in diameter. We prefer those with "loose sleeves," as they have the advantage of securing a more uniform drain surface than can be obtained in pipes with fixed collars, and they also allow greater facility in removing for cleaning or repairs. Instead of cast iron hinge blocks built into the brick work for support of doors, we are using wrought iron hinge eyes, of such shape that they furnish as secure a hold and are not open to the objections of cast iron. We have adopted white pine floor beams throughout, instead of white oak, as we find that they last just as well in damp situations and are less expensive. The track stringers we still make of white oak, as they hold the spikes much better than pine. In regard to double flooring, it was originally laid in this way so that when the upper floor wore out it could be removed and renewed, the sub-flooring being saved. We find, however, that where much water is used, as in the locomotive house, it gets in between the floors and very much increases the rapidity of decay. Single flooring would, therefore, seem to be the best. From trials now being made, however, it seems probable that some variety of asphalte pavement will take the place of timber flooring altogether for shops, and prove the best material yet adopted.

In roof trusses for locomotive houses we are now using a 7 inch

deck beam, weight 58 lbs. per yard, for the principal rafter, instead of the 6 inch I beam of 40 lbs., and the struts are of wrought iron instead of cast. We also connect the trusses together at the ridge by a 7 inch deck ridge beam, weight 48 lbs. per yard, so that in case of fire, and the roof of the building burning off, the trusses will keep their places.

Gutters of double cross roofing tin, as described in the locomotive house, are now used altogether. The use of copper has been abandoned on account of the cost and the trouble caused by its great expansion and contraction under changes of temperature.

The conductors from the gutters are now always run down on the interior of the building, as it lessens the danger of freezing up in winter. Turn-tables 60 feet in diameter have been adopted for all locomotive houses.

Galvanized iron cornices have been adopted entirely for shop buildings, as a great safeguard against fire communicating from one building to another. All of our later shops are heated by steam, direct radiation, and the method has been found very satisfactory.

The pitch of roof in these shops is generally too low, and we have adopted as a uniform pitch for slate roofs, rise of roof equal $\frac{1}{4}$ the span. We are also using smaller slate than given on these buildings, the larger slate being more apt to break and cause leaks. Very good sizes are 8 by 16 inches and 9 by 18 inches. As regards the roof truss of the locomotive and machine shop, we would remark generally upon roofs, that we are adopting iron roofs wherever we can, using timber roofs only where we suspend shafting and machinery from them, the greater stiffness of the wooden tie beam being advantageous here, although we may eventually use iron even for these cases. The so-called counters, introduced in the sloping portion of the roof, Plate V, are of no use, as not necessary to the system, and should be left out. The purlins in this roof are entirely too large, three by seven inches being plenty large enough for the distance of the trusses apart.

In the second story of the store house the ventilation is not sufficient for hot summer weather, and either windows or extra ventilators should be introduced.

In the roof truss of passenger car shop some of the timbers are unnecessarily heavy, and they might be made lighter in a future roof of the same kind. We have now adopted the system of filling in the gable ends of our shops, above a line level with the eaves, with heavy

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sash, glazed with rolled glass ¼ inch thick, adding much to the light of the interior.

In large shops we also introduce sash in the roof in long rows parallel with the length of the building and six or twelve feet wide, having the same slope as the roof. The glass used being ⅜ inch, rolled.

Freight car repair shops we are now building in a circular form, on the same principle as the locomotive house, with a turn-table in the centre, the depth of building being sufficient for three freight cars on each track. We find them much more convenient in every respect where large accommodation is required, and these circular buildings are cheaper than any other form for the same amount of floor surface.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

A regular meeting of this Society was held at its rooms, in New York, January 15th, 1873.

A paper by Casimir Constable, C. E., of New York, "On Retaining Walls; an Attempt to Reconcile Theory with Experiment," illustrated by a model, was read.

A retaining wall is stable when the moment of its weight about the point of rotation exceeds the moment of a certain triangular prism of material back of the wall about the same point—the intersection of the line of rupture of the wall, and the resultant thrust of the prism.

Many formulæ and tables for retaining walls are presented for use without a factor of safety, since walls proportioned therewith, well built and carefully "back filled," have been permanent.

Experiments made on a small scale, in which the theoretic conditions were more nearly fulfiled than in practice, show that such walls are more than stable, and point out the reason why.

The problem having been thus solved, a factor of safety may be introduced in the formula, which will allow for shocks, irregular workmanship and uncertain material.

The problem may be considered under these several heads: the angle of rupture, the height of the prism of rupture, and the direction and point of application of the pressure of the prism.

Angle of Rupture.—This was first supposed to be the angle of repose with the vertical; the thrust was assumed to be horizontal, and at two-thirds the height of the wall.

Belidor assumed the angle at 45°, and that the earth moved in layers parallel to the line of rupture.

Coulomb first considered the slope of earth, with the attendant physical conditions. His theory, as amplified by M. de Prony, is discussed by M. Gauthey, who gives a clear analysis of the angle of rupture.

Supposing the resistance of cohesion is proportional to the surface of rupture, and the friction to the normal pressure, the pressure against a retaining wall is that of the prism of earth, which would at once fall if the wall were removed. The inclination of the plane of separation of this prism will vary with the cohesion and friction of different earths. If a series of planes be conceived less inclined than that of repose, and originating from the same point, one of them will have such a position that the separating prism will have need of a greater opposing force to its sliding motion than any other.

Upon this hypothesis it is proved that the prism of greatest pressure is given by the plane which bisects the angle of repose, and that

$$P = \frac{1}{2} w_1 h^2 \tan^2 \frac{i}{2}$$

in which P = the horizontal force which sustains the prism; w_1, the weight per cubic foot; h, the height; and i, the angle of repose of the prism.

Lieut. Hope found, with layers of colored sand, the average angle of rupture to be 24°, and of repose 54°. This small difference in practice from theory is probably due to the cohesion of particles, an element which, from lack of sufficient data, is generally disregarded.

Height of Prism of Rupture.—From the first it has been assumed that the wall turned over as a solid mass about the bed joint at its base. In practice it is not so; the line of rupture is a stepped line, in or near the natural slope, and leaving a part of the wall undisturbed.

For experiment, a box 16″ high and wide, and 24″ long, with glass sides, was made. A miniature wall of pine blocks or "bricks," 1″ square, 2″ and 3″ long, with a bank of oats or peas, instead of earth, in eight trials turned over as stated. When the wall began to move the face bulged out, the centre of the curve being at about one-half the height, and would continue thus until started forward by a jar. This, due to cohesion of the backing, doubtless adds materially to the stability of walls of long standing, which, it is often noticed, stand, although bulging outward. (This and subsequent statements were illustrated by experiment).

A solid wall with a joint at the place of separation was more stable than one of "bricks," for, although each began to move at the same time, the first did not continue to give way, and required to be continually started.

Navies seems first to have noticed that walls rupture in this manner. It is reasonable that the prism of pressure should start at a point above the foot of the wall, for, by rotation of the wall about the outer point in the base, the lowermost portion of the backing must be lifted.

Experiments made in the case of surcharged walls gave heights agreeing very closely with those calculated upon this basis; while assuming the prism of pressure to start from the foot of the wall would give a height far below that sustained.

Direction of Thrust.—If the weight of prism of greatest pressure be resolved into two components, one normal to the slope of rupture, and the other to the back of the wall, the first will resist by its friction the tendency to slip along the slope; the second is expressed by the formula given, and may be resolved into two other components, one inclined, the actual thrust against the wall; and one vertical, to overcome the friction along the wall. This latter, from the indefinite knowledge of the value of the coëfficient, is generally neglected. The point of application of thrust, at first assumed to be one-third the height of the prism of pressure, which gave too great thickness to the wall, has been shown by Rankine and others to be at one-third the height from the foot. The height of the prism of pressure will be from ·70 to ·75 of height of wall. The conditions of the problem are now determined, from which follow these formulæ:

$$\frac{t}{p} = -\left(n + \frac{n^1}{2}\right) \pm \sqrt{\frac{2\tan^2\frac{d}{2}}{7w}\left(w_1 + \frac{8p}{3}\right) + \frac{n^2}{3} - \frac{n^2}{12}}$$

in which t = thickness at top of wall, p = any weight per square foot of surface distributed over the bank, n = batter per foot in height of outside, and n_1 = the same of inside of wall; d = angle of repose, w = weight per cubic foot of masonry, and w_1 = same of earth. If n and $n_1 = o$

$$\frac{t}{p} = \sqrt{w + \frac{8p}{3}}\tan\frac{\alpha}{2}$$

and if $p = o$

$$\frac{t}{p} = \cdot 53 \tan\frac{\alpha}{2}\sqrt{\frac{w_1}{w}}$$

This would have been ·57 instead of ·53 in case the prism was assumed to start from the foot of wall.

Rankine's theory of earth pressures makes the thrust parallel to

Mr. J. e gave a practical rule, verified by his experience, fo alls of dry masonry, less than 18 feet high:

namely, a width of 3 feet at top, a batter of $\frac{1}{6}$th outside, and none inside. In one case, for a mortared wall 18 feet high, he reduced the thickness at the top to $2\frac{1}{2}$ feet, and gave a batter to both sides. Engineers who, from lack of room, have been compelled to lay walls upon narrowed or stepped foundations, will be pleased to know, from Mr. Constable's experiments, that such conform to theory, and are safe in practice.

Mr. Collingwood inquired whether it was not best to step the back of a wall, rather than give it a batter.

Mr. Constable said it was more a matter of practice than of theory, by thus stepping a wall; the back-filling, upon settlement, did not act as a wedge.

Mr. Steele said that generally now the back of a wall is not stepped as formerly, but made vertical; often in railway practice it is counter sloped or under cut, and the stability thereby increased. The back should have a "frost" batter at top, where the earth is likely to freeze, so that it may be lifted from the wall; care should always be taken, in back-filling, to slope the packed earth from the wall rather than towards it.

Mr. Colman said that in filling behind the masonry of the N. Y. State canal locks, broken stone one foot in thickness had been placed between the wall and embankment.

A communication was submitted from a prominent Canadian engineer, in which he said, "In practice I have always made my walls heavier than theory demanded, on account of the severe operations of frost in this northern latitude, where it strikes from three to four feet into the ground, and yet without giving a slope or "frost" batter to the back of the wall where the frozen earth presses against it, our strongest walls could not stand. It has been my rule to make the base of the wall equal to $\frac{2}{5}$ its height, but this is for first class masonry laid in hydraulic cement."

Mr. Constable, by experiment with the model, demonstrated that two walls of same area of section, one rectangular and the other with batter on the face of $\frac{22}{100}$, were equally stable, and also that the saving in material by giving much batter is but little. A wall battered on the back less than on the face, evidently is less economical than if all the batter was on the face.

Attention was called to the difference in resistance to crushing per square inch of section, of stones 1″ and $1\frac{1}{2}$″ cube, as stated in Mr. C. B. Richard's paper, recording "Experiments on the Resistance of

Stones to Crushing," read before the Society January 8th last: thus, white marble gave a mean resistance in the first of 5812, and in the second of 8294 pounds per square inch of section. The question was raised, what relation was there between the size and the resistance of specimens, and whether tests upon blocks proportioned like those used in any particular work would better enable the engineer to determine how much the latter could withstand?

Tests of the strength of any material are of greatest value when conducted under conditions most like those governing actual use. The difficulty of making such upon large specimens was pointed out, and a brief of testing machines was given.

It was proposed to take up the latter as a subject of discussion at a future meeting of the Society.

Iron Electrotypes.—We learn from foreign journals that considerable attention is being at present directed to the production of iron plating, the result being quite satisfactory. It appears, from a consideration of the subject, that there are many purposes in the arts for which an iron plating would be superior to any of those now known in electro-chemistry.

It is stated that at the recent Exhibition (1871) at London there were exhibited bank-note plates, medallions, and a page of printing type electrotyped in iron by a process devised by M. Eugene Klien.

The importance attaching to a successful solution of the problem, especially in the direction of engraving and printing, were recognized by the inventor, who had zealously labored at the work for several years with varying success.

The medals first produced showed on their reverse side, porosities and deep hollows, which penetrated nearly through the thickness of the deposit. In the later productions these were entirely absent.

Concerning the practical application of the iron electrotype, much is expected. By replacing plates of copper by those of iron, greater facilities will be offered for producing such work as bank-notes, checks, and the like, since the iron plate is found to be almost indestructible.

Not only can they be printed from, an unlimited number of times, but they are better able to withstand those inevitable accidents to which plates are subjected in printing establishments, where often a trifling circumstance renders them useless, and involves much and often serious delay in publication.

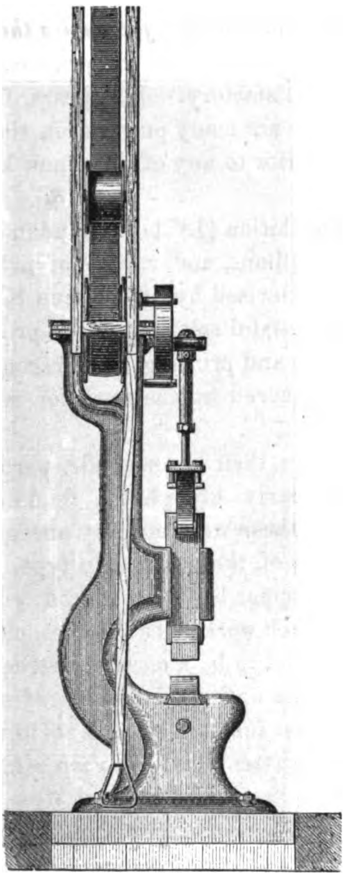
BELTING FACTS AND FIGURES.

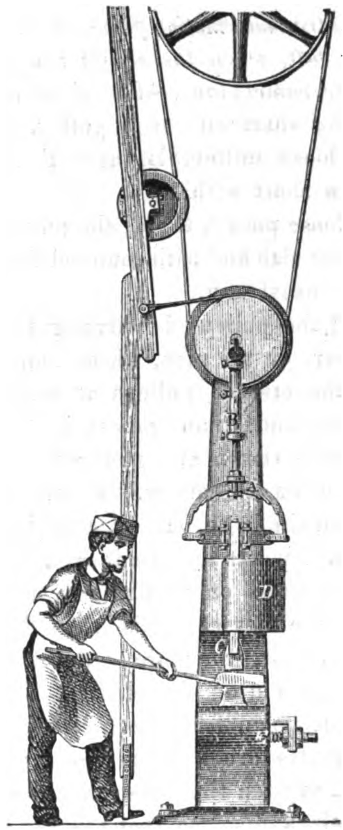
By J. H. Cooper.

(Continued from page 105.)

Imparting and arresting motion.—Mr. Thomas Shaw's dead stroke power hammer illustrates the application of the belt for giving to and taking motion from a shaft at the pleasure of the operator. The same devices can, however, by an easy transition, be applied to other machines.

In this the driving pulley, carrying a loose belt, is on a line shaft over the driven flanged pulley, which latter is on a shaft at the top of the hammer frame. This shaft carries a crank wheel actuating the hammer, as shown, and is partly invested by a leather band for arresting its motion. One end of this band is secured to a pin in the

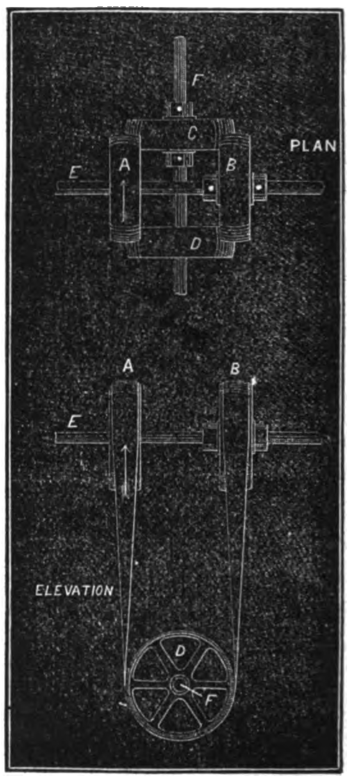




hammer frame under the crank wheel; the other end is fastened to the swinging lever, to which also the tightener pulley of the driving belt is applied.

The action of these belts is produced by opposite motions of the lever; thus, when the operator pushes it, the arresting band releases the crank wheel, and the tightener pulley presses upon the driving belt, which, being constantly in motion, applies its adhesion to the pulley on the crank shaft and propels the hammer, and it does this with a varying velocity, according to the pressure upon the tightener. Withdrawing the lever relaxes the driving belt and tightens the arresting band. These motions are under the easy control of the operator, and such is the nature and action of the belt, in this application, that these motions can be repeated rapidly and effectively without destructive wear to any part of the machine.

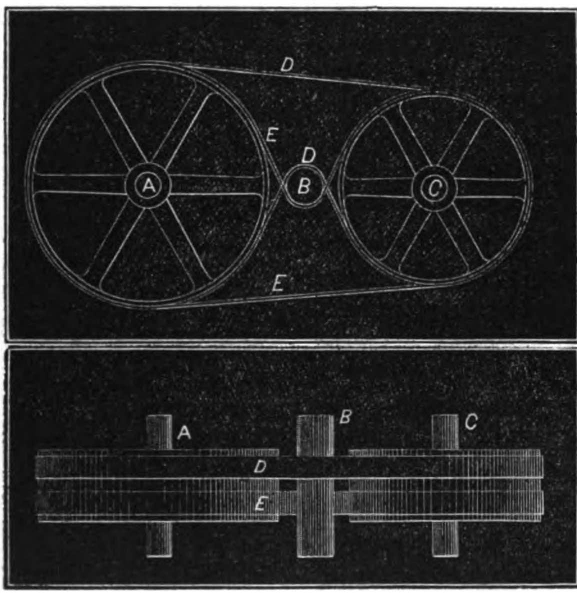
To transmit motion from one shaft to another at right angles thereto, by a belt, when the shafts are not in the same plane.—Let E be the *driving* shaft with tight pulley, A, and loose pulley, B, and F the *driven* shaft with tight pulley, D, and loose pulley, C; all the pulleys of same size and with rounded face in the usual way.



Let the pulleys be arranged in a square on the plan, whose side is the diameter of pulleys at centre of face, and let an endless belt be put on as shown and run in the direction of the arrow. It will be noticed the loose pulleys, C and B, run in opposite directions from that of the shafts on which they turn, but since they carry the slack fold of the belt, they are relieved of heavy strain on the shafts. This is a good plan for wide belts when the shafts are a proper distance apart, say ten times the breadth of the belt, and solves that sometimes

difficult problem of carrying considerable power around a corner by a belt. There is no loss of contact of the belt on any of the pulleys of this system, and no lateral straining and tearing of the fibres of the belt as in the usual quarter twist arrangement in which only two pulleys are used. The lower shaft may drive the upper one, as well, by changing the direction of motion, or changing the relative positions of the tight and loose pulleys.

Weaver's belting.—The object of this arrangement is to obtain high speed in a shaft directly from a driving pulley without the aid of intermediate counter pulleys or gears, and with reduced lateral stress on the bearings of the driven shaft.



A, B and C show three shafts parallel to one another. A and C carry straight-faced pulleys, upon which run two belts of equal length and width, separated to prevent contact with each other while running. The lower fold of belt, D, is carried *over* the shaft, B, and the upper fold of belt E is carried *under* B, and each, in running, imparts motion to the driven shaft in the same direction, and at the same time balancing the lateral pressure on its journals.

A is the driving shaft with large pulley; B the driven shaft of comparatively small diameter, and C, a counter shaft, with its pulley

of any convenient diameter, is placed in position to carry and return the belts, and may be moved and secured to and from B by screw adjustment or otherwise, to secure proper tension of belts.

Combined fast and loose pulley for round belts, by John Shinn, of Philadelphia.—The round belt, *f*, fits in a groove formed between two half pulleys, of which A′ is fixed and A slides upon a fixed key on the shaft, B; between A′ and A, and running loosely on the shaft, is a flat-faced pulley, C; when A is separated from A′ a short distance, the belt, *f*, will cease to turn them, and will run on and turn C instead. The belt drives the shaft, B, only when pinched between the half grooves of A′ and A. The lever, D, when moved in the direction indicated by the arrow, withdraws the half sheave, A, and permits the belt to run on the loose pulley. Simple and efficient means for holding the parts together and drawing one half from the other, are shown in the cuts.

Fig. 1

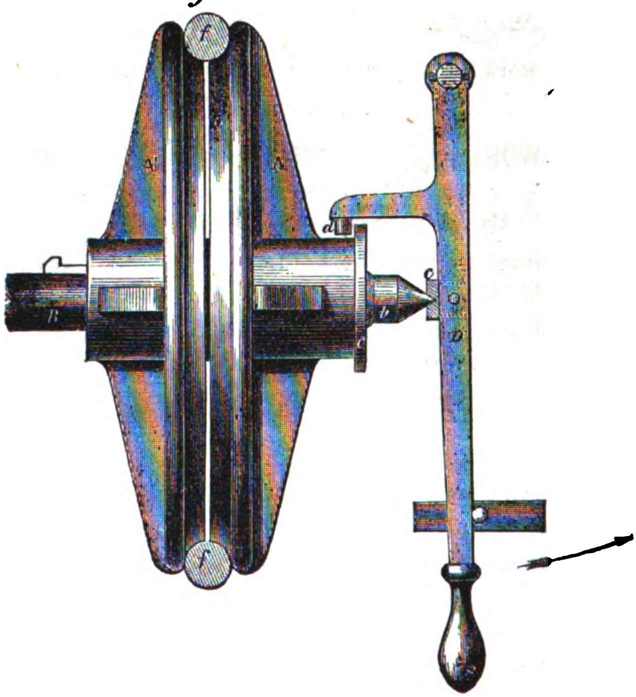
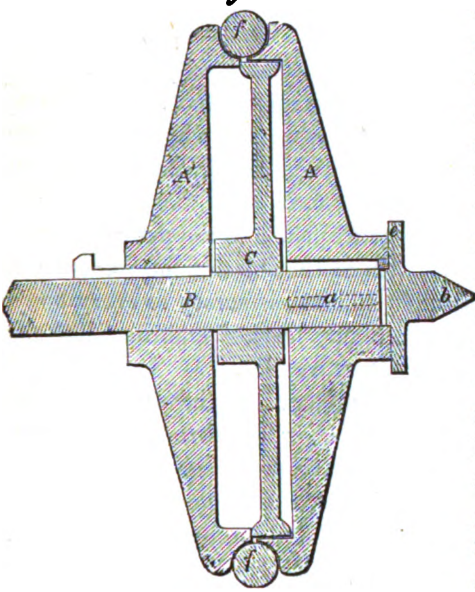


Fig 2



It is not proposed, of course, to drive very large and heavy machinery with round belts, such as are required for this description of shifting pulleys; but, as far as a round belt will go with advantage, these pulleys will be found of the greatest service. Thus, the round belt cuts off less light, occupies less room, makes smaller holes in the floors, requires lighter driving pulleys to carry it, and thus saves power; while, as regards the driving power of round belts, we have seen one, of an inch diameter, doing for years work which proved too much for a 7-inch flat belt.

TEST OF THE WORTHINGTON PUMPING ENGINE AT BELMONT, PHILADELPHIA.

By W. Barnet LeVan, Engineer.

In a paper printed by this Journal in the April number, from the pen of William M. Henderson, Hydraulic Engineer, it appears that the tests made of the Worthington engines for the purpose of ascertaining their duty between May 15th and 17th, 1872, by a commission of experts, consisting of mechanical and hydraulic engineers, appointed by the city Councils of the City of Philadelphia, are very unsatisfactory to the writer of that paper.

He discovers a discrepancy between the experiments and calculations of the experts appointed by city Councils, five in number, and the deductions made from the same experiments made by a single engineer, who was associated with this commission by the city Councils, through a request made by the Citizens' Reform Association.

The latter seems to be in the situation of taking sides with that twelfth juryman, who complained about his eleven associates, who were so contrary that they did not agree with him.

Five gentlemen say that these engines actually performed a duty of fifty four millions four hundred and sixteen thousand six hundred and ninety-four pounds.

One gentleman says that they only performed a duty of forty-four million six hundred and seventy-nine thousand pounds. A majority of these five gentlemen were present during the whole forty-eight hours and twenty minutes—the time of the experiments. The one gentleman was present only *part* of the time.

Now it would seem that under general principle the determination, by experiment, of so simple a problem as that of the duty of a steam engine, pumping water up hill, ought to be satisfactory to every body, particularly as these gentlemen are highly learned and distinguished for their knowledge of machinery and hydraulics.

But, since it has been found, before to-day, that, in matters of science and the engineering art, majorities have been wrong, I therefore conclude, by a short paper, to answer Mr. Henderson.

His calculations put me much in mind of those old arithmetical puzzles, that are invented to amuse the learned and confound the ignorant. One of them is that of putting twelve lodgers in a hotel in eleven beds, one bed in each room and eleven rooms, and only one in each bed.

What duty means.—Mr. Henderson states that where he uses the word duty he means the same thing as the commission of experts meant, namely, the number of pounds of water raised one foot high by the consumption of one pound of coal; he refers to the Charlestown water works for the past year, which gives the average duty of the Worthington Duplex Engines at about 70,000,000 pounds.

It appears that this pump at Charlestown, smaller and more insignificant, as compared to the Belmont pump, made and placed there by the same maker, Mr. Worthington, has produced a duty of about seventy millions.

It would seem most natural that these five contrary men, in making the test at Belmont, with pumps and machinery placed by the same maker, of larger capacity, with finer appliances, with better mechanical attachments; it would seem strange, I say, that the Belmont pumps should not do somewhat near an equivalent duty to those at Charlestown.

The price bid.—He speaks incidentally of the price of the bid of a New York firm for ninety-five thousand dollars, and that of the Messrs. Merrick fifty-seven thousand dollars.

The casual reader would understand, most likely, that these bids were for the same work—indeed, his paper says so—while the truth is that the form, character and duty of these engines, as guaranteed by these gentlemen, were as wide apart as their bids were.

Annual Duty.—The duty, called the annual duty by the writer of the paper under discussion, as he determines it from the reports of the late Chief Engineer, is 38,000,000 and a fraction, and he complacently says, "Now the duty of these engines are pretty well established," and that "the duty of 67,969,000 has not been obtained and cannot be obtained," and therefore the report of these five experts is either the work of a set of ignoramuses, or is a deliberate fraud upon the public.

In the first place, the test of duty, under the contract with Worthington, was to be for a duty of fifty millions pounds in twenty-four hours continuous run; height 208 feet, exclusive of friction.

The duty to be determined was the maximum duty of the engines, the same as in the purchase of a horse that is guaranteed to trot a mile in 2′ 18″.

The contract is filled if the horse performs that amount of duty.

Coal.—Coal to be used for a test should be screened, and should be of the best quality. Otherwise, if leaway were to be given as to the quality of coal to be employed in the test, advantage might be taken of the engine builder by furnishing the poorest, dirtiest and most worthless quality of coal to be employed for the test.

The test.—A test should be made in the beginning by starting with clean fires, and at the close the fires should be in the same condition as at commencement. The amount of water evaporated per pound of coal consumed is an incidental affair, and has nothing to do whatever with the duty or work of the engine. *The elements of the work of the engine is the amount of weight it has raised to a certain height by a certain number of pounds of coal.*

Therefore, whether the engine evaporated 9½ or 7½ pounds of water to a pound of coal, is not in the question of the duty of this engine.

Ashes, coals, &c.—As to calling one-third of the ashes, coals (1450 lbs.), that was a matter of the judgment of five experts against one, as five contrary men to one.

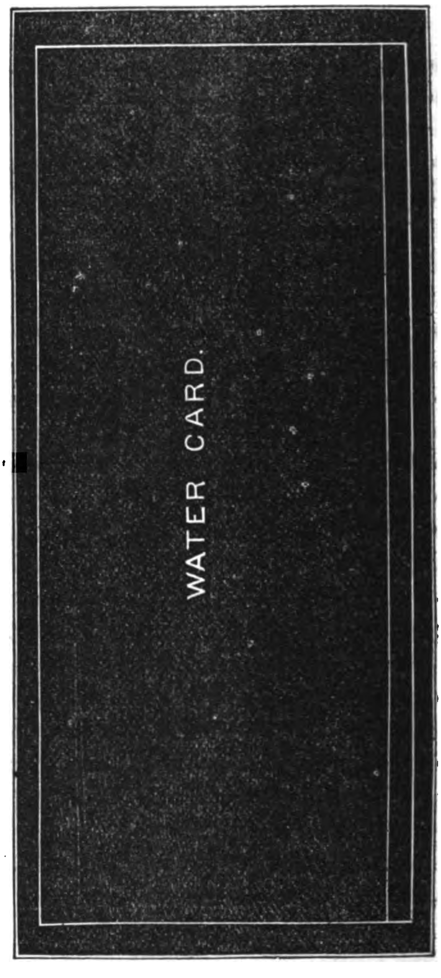
Forcing engines.—Forcing the engines continuously to within five-sixteenths of an inch of the cylinder heads, showed how exquisitely fine their mechanism was.

Manipulation of feed pump.—The several witnesses who saw a

manipulation of the feed pump which supplied the boilers with water, were the five witnesses who did not see it, and the one witness who was not there and *did* [redacted] see it.

Error at weir.—As to the error detected by the citizens' expert in the measurement of water delivered over the weir, it is but fair to be said that the citizens' expert saw the weir but occasionally, while the majority of the five experts and their assistants saw it every five minutes for the entire forty-eight hours and twenty minutes.

Capacity of pumps.—The capacity of the pumps are not independent *of the actual delivery of water into the reservoir,* because that capacity in work done is what delivers water into the reservoir.



The writer (Mr. Henderson) of the paper I am criticizing will understand that there is no enacting of a tragedy of Richard with "Richard left out" in the pumping of water by steam. He knows, as well as I do, that if he makes his Richard a steam engine, and leaves him out, no water will ascend the hill.

Height of main.—The writer says that the height of the force main is 217.14 feet, and that is incorrect, and that the height is actually but 208 feet. It is unnecessary to say to the scientist that the difference is the extra height due to friction, which these five contrary men determined upon.

The annexed indicator diagram, taken from rising main just as the water left the pumps, shows the working conditions of the pumps.

Captain Loam, who has had a large experience in the testing of Cornish engines, stated to a large engine builder in this

city, that when a test was to take place, preparations were made weeks in advance, and then the trial only lasted a short time, and the delivery was arrived at by calculations, and not by measurement.

It will be seen by the above that the average duty of the Cornish pumping engines is near about from thirty to forty million pounds; that the high duty mentioned by Mr. Henderson refers to those Cornish pumps that draw their water from deep mines, from 1,000 to 2,000 feet in depth.

Their process of working is simply the act of lifting the water from these deep pits by a slow and easy process, the steam acting only to raise the heavy weights that are attached to the long line of rods and pumps that extend into the deep pits below.

The strokes of these engines are generally regulated about in the proportion to the water that flows into the mine, and generally they run at the rate of from one stroke in a minute to one stroke in five minutes.

Therefore, I say that the comparison, as instituted between the Holmbush engine and that of the engine as at Belmont, is as though one were to make a comparison between the duty performed by a giant doing a small amount of work in proportion to his strength, and the little worker, who is active, determined, efficient and accomplishes much more by the expenditure of less vital force. The writer of the paper which I criticise says that he considers it a duty to place the subject of the test of the Belmont pumps in its proper light before the community.

I am afraid that his light is simply the single light (sperm candle, as I suppose), overshining the lights of those five contrary men who seem to believe that if you lift 93,485,513 pounds of water 208 feet high, adding nine feet for friction, by 38,890 pounds of coal, results in 54,416,694 duty. I am afraid that his light, however so brightly it may shine, will not do otherwise than show that this awkward set of ignoramuses, who determined the duty of these engines, both by experiment and calculation—these five men, who were so contrary and who chose to differ with this one man, were right.

I think it will be clear that if the test is made again, which the writer, Mr. H., so particularly desires, it will be found that these five contrary men were right.

I append below a copy of the letter from the gentleman who furnished the coal for the experiment. He declares that it was only ordinary coal. It should have been, by rights, properly screened and picked for the experiment, for that was but simple justice, if it had

been so done, to the manufacturer of the engines at Belmont. But it was not so done.

Philadelphia, April 4th, 1873.

PHILADELPHIA, *July 24th,* 1872,
314½ Walnut street.

F. GRAFF, Chief Engineer City Water Department.

Dear Sir:—In reference to the coal spoken of in H. P. M. Birkinbien's report of the trial of the Worthington pumps at Belmont, we would say that the coal was shipped direct from the mines in cars No. 1484, 2942, 4362, 2699 and 2617, April 20th, and was delivered in your schute at the works April 23d, by the Pennsylvania Railroad Company. The coal was the ordinary run of the mine, and was sent without any extra care or preparation whatever, and the same quality can be had at any time or in any quantity by simply giving the order; therefore the assertion in the report that the coal was prepared for the occasion, is simply a misstatement. The coal was from the Shawnee colliery, near Wilkesbarre.

Very respectfully yours,
[Signed] W. D. HESTON, & Co.

The coal referred to above was wheeled into the engine house near the scales immediately upon its arrival, that it might be convenient for use. I certify that it was not "*selected, screened or picked,*" as represented by Mr. Birkinbine.

[Signed] FRED. GRAFF,
Chief Engineer Water Department.

NOTES ON THE RESISTANCE OF BRICKS TO A CRUSHING FORCE.*

By GEORGE S. GREENE, JR., C. E.

The bricks were of the kind used in the construction of the South Gate-House of the New Reservoir in the city of New York, by Fairchild, Walker & Co., contractors.

The experiments were make by Gen. George S. Greene, at Cornell & Co.'s, Centre street, September 20th, 1860, in Hatfield's Hydraulic Press for testing building materials, built by R. Hoe & Co.

The bricks were what are known as hard brick, and manufactured at the yard of Wm. Call, Haverstraw, on the Hudson river; they are regarded as average samples of the mass of brick used in the construction of the Gate-House. The experiments were not made in the interest of any person, but solely to determine the actual strength of the brick. In order to bring them within the power of the machine, but little more than half of a brick was used. The pieces of brick were

* From American Society of Civil Engineers.

first dressed by a stone-cutter, and then ground down on a grind-stone. The faces exposed to pressure were not perfect planes, and therefore a layer of wood and sand was interposed between the faces of the machine and those of the bricks.

Dimensions of the Brick used in Experiments, in Inches and Decimals.

	THICK. WIDE. BROAD.				
No. 1.	—2.30 x 3.52 x 4.40	15.488	sq.	in. exposed	to pressure.
No. 2.	—2.24 x 3.50 x 4.46	15.610	"	"	"
No. 3.	—2.34 x 3.50 x 4.52	15.820	"	"	"
No. 4.	—2.34 x 3.46 x 4.46	15.4316	"	"	"
No. 5.	—2.30 x 3.46 x 4.50	15.570	"	"	"
No. 6.	—2.28 x 3.46 x 4.60	15.916	"	"	"

No. 1.—At 30,000 lbs. (= 1.937 lbs. per sq. in.) cracked in centre; kept at 50,000 (= 3,228.3 lbs. per sq. in.) without crushing. Brick between two pieces of board, half an inch thick.

No. 2.—Had a layer of sand. Sign of crack at 50,000 lbs.(= 3,203 lbs. per sq. in.); kept at 52,500 (= 3,362.2 per sq. in.) for three minutes, but did not crush. Crack did not extend through brick, nor was it broken into two parts.

No. 3.—Crushed to pieces at 43,500 lbs. (= 2,749.7 lbs. per sq. in.); packed with sand.

No. 4.—Packed with two pieces of cigar-box wood; edges crushed off at 30,000 lbs. (= 1,994.1 lbs. per sq. in.)

No. 5.—Packed with sand; cracked at 27,000 lbs. (= 1,734.1 lbs. per sq. in.); crushed at 32,000 lbs (= 2,055.3 lbs. per sq. in.) Brick crushed and cracked in all directions; did not fall to pieces as did No. 3.

No. 6.—Packed in sand; commenced to crack at 30,000 lbs. (= 1,884.9 lbs. per sq. in.); crushed to pieces at 46,500 lbs. (= 2,921.6 lbs. per sq. in.)

An Indelible Ink.—M. Böttger has published the observation that an excellent indelible ink can be prepared by taking a quantity of aniline black, triturating the same in a porcelain mortar with a few drops of alcohol and hydrochloric acid, and mixing it with a hot solution of gum arabic. The same observer declares also that if, instead of gum arabic, shellac is employed, the preparation will make an excellent enamel for wood and leather.

EXPERIMENTS ON THE RESISTANCE OF STONES TO CRUSHING.*

By C. B. Richards, M. E.

The accompanying tables present the data and results of experiments made by direction of General Franklin, at the Colt Company's Armory, to ascertain the relative resistance of various American building stones to crushing.

The specimens were furnished by Mr. J. G. Batterson, and were shaped with great accuracy at his marble works in this city. They were selected from old and dry stones of the best quality of their kinds, and were worked into nearly perfect cubes with very flat and smooth faces. Two different sizes of cubes were tested, their edges measuring very nearly one inch and one and a half inch respectively.

The testing machine used in the experiments is one designed by the writer for the Colt Company, who had it constructed for use in their Armory, both for testing materials used in their own manufactures, and also for making tests for the engineering public. As a description of this machine was published in the "Scientific American," of March 26th, 1872, and in several other mechanical periodicals, it is unnecessary to describe it here; it is only desirable to state that the apparatus for weighing the strains consists of a very sensitive platform scale of fifty tons capacity, and that the machine was built after a long experience with two smaller, similar machines, one of which was constructed by the writer as early as 1867. Experience with this large machine in operating on hundreds of specimens, has proved it to be admirably adapted for accurate research, and leaves no room for doubt as to the correctness of its indications.

The fixtures between which the stones were crushed consist of hardened steel hemispheres, with their curved surfaces seated in corresponding cavities made in steel blocks, which are fixed in the testing machine. These hemispheres can rock in every direction, and their flat surfaces, therefore, accommodate themselves to the direction of the surfaces of the specimens.

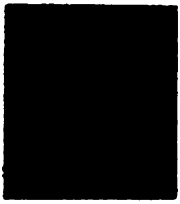
Single thicknesses of thin "lace" leather were applied between the steel and stone surfaces to ensure uniform distribution of the pressure upon the specimen.

The pressure was in all cases applied to those surfaces of the cubes which were parallel with the natural bed of the stone.

Table 1 gives the description and dimensions of each specimen, the strain required to crush it, and the resistance per square inch deduced from the area crushed and the crushing strain.

* From American Society of Civil Engineers.

The sides of the cubes and their dimensions referred to in the table, columns 3, 4, 5 and 6, are indicated by letters, as shown in this diagram.



The side on which the pressure was applied is shown in each case in the table by the letter in the sixth column. The area of the surface on which the pressure was given, will there be obtained from two of the three dimensions given in the third, fourth and fifth columns, as follows:

$$\text{If the pressure was exerted on } \left\{\begin{matrix} a \\ b \\ c \end{matrix}\right\} \text{ the area} = \left\{\begin{matrix} a \times b \\ b \times c \\ c \times a \end{matrix}\right\}$$

Table 2 exhibits a resumé of the results of all the tests, grouped according to the kind of stone and size of specimen; giving the minimum, average and maximum resistance per square inch of all the specimens of each kind.

All the specimens failed by breaking up into slender prisms and pyramids whose axes were normal to the surfaces on which the pressure was exerted. Specimen, No. 8 (Table 1), split into four parts with a strain of 6,250 lbs., and afterwards sustained an additional load of 5,210 lbs., without other indications of failure.

Several other specimens split into two or four nearly equal parts, with loads somewhat less than those which ultimately produced crushing.

In all cases the strain was gradually applied, and increased to the crushing point by pouring shot into the apparatus by which the pressure is produced.

It will be noticed that several of the specimens broke with strains of even thousands of pounds. This coincidence probably arises from the fact that it requires some seconds of time to move the large weight on the weigh-beam of the testing machine, and this needs to be moved for every two thousand pounds increment of strain (the intermediate pressures being otherwise indicated at the beam). While this change is being made, the strain then exerted is maintained unaltered, while at other times the strain is continually though slowly increasing. It is reasonable to suppose that if the specimen is slowly giving way while the adjustment of the weight is being made, opportunity is then given for it to yield and fail at the pressure then on, which will be at some certain thousand of pounds; but if the strain had been slowly increasing during the time while the specimen was yielding, the indication of the machine would have been a few pounds higher.

Hartford, Ct., January, 1873.

TABLE 1.

No.	KIND OF STONE.	Dimensions. A	Dimensions. B	Dimensions. C	Side on which the press'e was appl'd.	Pressure at which crushing occurr'd.	Resist'e to crushing per square in.
		in.	in.	in.		lbs.	lbs.
1	White Marble from Canaan, Ct..........	0.980	0.990	0.990	a	4.810	4.958
2	do. do.	1.000	0.963	0.980	b	6,280	6,654
3	do. do.	0.990	0.998	0.963	a	5,000	5,060
4	do. do.	0.997	0.990	0.992	a	6,500	6,585
5	White Marble from Alford, Mass..........	1.000	0.998	1.005	a	5,000	5,010
6	do. do.	1.002	1.005	1.004	b	3,940	3,905
7	do. do.	1.000	1.005	1.000	a	5,990	5,960
8	Blueish Marble from Lee, Mass.........	0 995	0.999	0.998	a	11,460	11,528
9	do. do.	0.984	0.998	1.000	b	7,690	7,705
10	Granite, from Westerly, R. I.............	1.000	1.008	1.004	b	19,000	18,778
11	do. do.	1.002	1.005	1.000	a	15,700	15,590
12	Granite, from Plymouth, Ct................	1.000	0.993	0.995	a	8,560	8,620
13	do. do.	0.997	0.995	0.997	c	10,350	10,412
14	Granite, from Concord, N. H.............	1.000	1.000	0.985	c	8,680	8.812
15	do. do.	1.002	0.983	1.003	a	9,690	9,838
16	White Marble, from Alford, Mass.......	1.000	1.004	0.997	a	6,000	5,976
17	Granite, from Quincy, Mass................	1.001	1.001	1.004	c	15,700	15,622
18	do. do.	1.005	0.996	1.001	c	13,000	12,923
19	do. do.	1.001	0.997	1.003	b	11,730	11,730
20	Granite, from Fox Island, Maine.........	1 000	1.004	0.987	c	14,000	14,185
21	do. do.	1.000	1.001	1.005	c	12,360	12,299
22	do. do.	1.007	1.000	1.005	b	12,900	12,836
23	do. do.	0.995	1.004	1.002	a	11,880	11,892
24	Granite, from Jonesboro, Maine.........	0.990	1.007	1.006	b	11,380	11,233
25	do. do.	1.007	0.994	1.005	a	12,320	12,307
26	do. do.	0.996	1.005	0.998	b	16,000	15,952
27	Sandstone, from Amherst, Ohio	1.002	0.988	0.995	c	7,740	7,463
28	do. do.	0.985	0.998	1.000	c	8,350	8 477
29	do. do.	0.992	0.991	0.999	c	8,050	8,123
30	do. do.	0.988	0.996	1.009	b	9,000	8,955
31	do. do.	0.996	1.002	1.004	b	6,180	6,141
32	Sandstone, from Portland, Ct............	0.993	1.003	1.006	c	5,800	5,806
33	do. do.	1.002	0.985	0.993	a	6,240	6,322
34	do. do.	1.004	0.097	0.996	a	8,260	8,252
35	do. do.	1.001	1.001	1.001	a	10,950	10,928
36	Sandstone, from Nova Scotia............	0.993	1.006	0.998	c	10,220	10,322
37	do. do.	0.999	0.997	1.005	a	7,130	7,158
38	do. do.	1.011	0.997	0.998	b	6,500	6,532
39	do. do.	1.005	0.998	0.998	a	9,220	9,193
40	do. do.	1.005	0.999	0.996	b	9.320	9,366
41	White Statuary Marble, Carrara, Italy..	1.494	1.487	1.493	a	21,600	9,723
42	White Marble, from Canaan, Ct........	1.476	1.483	1.493	a	19,250	8,794
43	do. do.	1.487	1.479	1.484	a	17,140	7,793
44	Sandstone, from Windsor, Ct............	1.489	1.488	1.484	a	22,000	9,929
45	do. do.	1.495	1.484	1.488	a	27,850	12,553
46	White Marble, from Derby, Ct	1.489	1.486	1.466	b	21,300	9 777
47	do. do.	1.486	1.478	1.490	a	18,900	8,605
48	Blueish Marble, from Lee, Mass.........	1.475	1.485	1.480	c	30,460	13,953
49	do. do.	1.480	1.476	1.483	b	39,300	17,954
50	White Marble, from Lee, Mass...........	0.993	0.998	0.988	a	12,800	13,916
51	do. do.	0.992	0.990	0.983	b	13 900	13,972

TABLE 2.

KIND OF STONE.	LOCALITY OF QUARRY.	Number of Specimens crushed of each kind.	Nominal size of Specimens.	RESISTANCE TO CRUSHING PER SQUARE INCH. Minimum.	Average.	Maximum.
			in.	lbs.	lbs.	lbs.
White Marble	Canaan, Ct.	4	1	4,958	5,812	6,585
do.	do.	2	1½	7,794	8,294	8,794
do.	Alford, Mass.	4	1	3,905	5,213	5,976
do.	Lee, Mass.	2	1	12,917	13,444	13,972
Blueish Marble	do.	2	1	7,705	9,616	11,528
do.	do.	2	1½	13,953	15,953	17,954
Granite	Westerly, R. I.	2	1	15,591	17,184	18,778
do.	Plymouth, Ct.	2	1	8,620	9,516	10,412
do.	Concord, N. H.	2	1	8,812	9,325	9,838
do.	Quincy, Mass.	3	1	11,730	13,425	15,622
do.	Fox Island, Maine	4	1	11,892	12,803	14,185
do.	Jonesboro, Maine	3	1	11,234	13,164	15,952
Sandstone	Portland, Ct.	4	1	5,606	7,826	10,928
do.	Amherst, Ohio	5	1	6,141	7,832	8,956
do.	Nova Scotia	5	1	6,532	8,512	10,322
do.	Windsor, Ct.	2	1½	9,930	11,241	12,553
Statuary Marble	Carrara, Italy	1	1½	....	9,723	....

APPENDIX.

The following additional communication from Mr. Richards, in reply to some inquiries, is here printed:

With reference to these experiments on stones, one object in having the specimens made of two different sizes, was to attempt to ascertain whether the size would affect the modulus of rupture. It was anticipated that the larger cubes would give the higher results, and this seems to be the fact. But, in the communication, attention was not called to this circumstance, because it can hardly be supposed that reliable average results can be obtained from a test of only two specimens, and there were no more than two of the large specimens of any one kind of stone. This doubt would apply particularly to cases where the extreme results vary so greatly as those in question. It is to be noticed in the tables that in some cases the minimum modulus for the large cubes is smaller than the maximum for the small ones of the same kind of stone.

It would be interesting to learn where the limit is, when an increase of the size of the specimen ceases to affect the modulus derived from the experiments. But I imagine that this limit would vary with the

different kinds of stone, and that the solution of the question would require a testing apparatus of considerable capacity. That the relative proportions of the specimens be made to correspond with those of stones commonly used in practical work, is undoubtedly important, and ought to be carried out. It seems probable, however, that even in this case, the thickness of the experimental piece ought to be considerable, say at least one and a half inches for some kinds of stone, and this would involve a large area to be crushed, and consequently require the application of great strains.

The more any one makes test of the strength of materials, the more he realizes the importance of being able to test large samples, and of having powerful testing machines, such as Kirkaldy's.

Since this communication was prepared, my attention has been called to experiments made by the Commission of 1851, on marbles, &c., for the United States Capitol Extension (see Architect's report, accompanying the President's message, 32d Congress, 2d Session, 1852.)

This Commission discovered the somewhat remarkable fact that the effect of pieces of sheet lead placed between the stone samples and the steel surfaces of the testing apparatus, was to occasion the failure of the specimen with about half the load it would sustain if pressed directly by the steel surfaces; that is, with the steel and stone surfaces in contact.

Now, in my experiments, thin leather was used between the stone and steel surfaces as stated. This leather must have become practically rigid under the pressure it sustained, as seems to be proved by the way the specimens broke up into numerous slender pyramids, and by the friable character of the whole substance of the fractured parts, which can in most instances be crushed to powder between the fingers. These conditions of the broken pieces seem to indicate that the pressure was applied in a way that caused all parts of the specimens to fail at the same time, which must be the case when steel surfaces are applied fairly to the stone. With lead interposed, the circumstances are different, because this metal retains its sotfness at such pressures as those in question.

THE MEXICAN METHOD OF MAKING HARD LIME FLOORS.*

By Gen. Theo. G. Ellis, C. E.

Some years since, the writer had occasion to visit Northern Mexico, to examine and work some silver mines; and, while passing through the Mexican villages, noticed the exceedingly hard and polished lime floors and roofs of the houses.

In the village of Salinas, where our party remained some three weeks, the horses passed daily through the house into the inner courtyard over one of these floors without leaving an indentation, or injuring it in any way. Some time after, having occasion to construct some buildings at La Yguana mines, an attempt was made to imitate these floors and roofs. Attributing the peculiar hardness and smoothness of the floors to the inherent good qualities of the lime used, no inquiries were made as to the Mexican method of working. A good quality of limestone was selected and calcined in the ordinary way. Shortly after burning it was slaked to a dry powder, and afterwards used as required. A floor was laid with a foundation of about three inches of broken stone, over which was evenly spread about two inches of mortar, formed of two parts of clean sharp sand, and one of lime. The lime was "fat," swelled greatly in slaking, and was not at all hydraulic.

The floor, made as above, was a total failure. At the end of four weeks the leg of a chair would indent it. As soon as the surface was damaged it began to crumble; and soon broke up. It would probably have been about as hard as our ordinary lime mortar if allowed to set a sufficient length of time before being used.

Knowing that the Mexicans used the same materials with better success, their superior skill was called into requisition to lay all the remaining floors and roof of the same building. They used the same sort of lime and sand in about the same proportions, and upon the same kind of foundation. The result was a floor as hard and smooth as a piece of polished marble, that a horse could trot upon without injury.

A brief account of the method of making these floors may not be uninteresting.

The limestone used was a hard, compact blue material, in some places sufficiently hard to strike fire on the drills used in running a

* From American Society of Civil Engineers.

drift through it for mining purposes. It often contains iron pyrites in small proportion. This was calcined in kilns cut out of a very soft limestone, that likewise is found in that section of country, and which on account of its whiteness and softness is called "cal leche." I believe it is never used for making lime by the Mexicans.

After calcination the lime was removed from the kilns and slaked as soon as cool. Some of it was used within a day or two, and some remained a month or more in barrels. All the work made with it seemed to be equally good.

In making the floors, a layer of broken limestone, three or four inches thick, was first laid evenly over the surface of the ground. The stone being about the usual size for macadamizing roads; over this a mortar of about two parts of sand to one of lime was carefully and evenly spread to the thickness of one and a half to two inches; this was allowed to remain for about twenty-four hours, or until the surface had become quite dry. It would probably take longer in this climate, where the air possesses a greater amount of moisture than in Mexico.

The floor was then thoroughly pounded all over with a tool composed of a block of wood about a foot square and three inches thick, having a handle rising from the middle, so that a man could stand while using it. The whole surface was beaten over with this ram until it was again as soft and moist as when first laid. This operation of ramming brought the water in the mortar to the surface so as to form a layer of semi-fluid substance on top.

The floor was again allowed to dry, and again beaten over each day for about a week, when the operation brought only a slight amount of moisture to the surface.

Immediately after the last pounding the whole surface was powdered with a thin layer of red ochre, evenly sifted on, and then polished as follows:

A smooth, nearly flat, water-worn stone, a little larger than the fist, was selected from the bed of the stream which ran through the place, and with this the whole floor was laboriously gone over, rubbing down and leaving the surface of the lime as smooth as a piece of polished stone; the red of the ochre rendering it of a rich brown color.

In less than a week the floors made in this way were sufficiently hard to bear the weight of a horse without indentation.

Roofs were made in the same manner without the coloring matter, which was added only to give the floors a better tint than the gray of

the mortar. These roofs were perfectly water-proof, and were unaffected by sun or rain.

In the city of Monterey, sidewalks in the principal streets are made in the same manner, and some of them have lasted for years, wearing through like a block of stone.

The great durability and strength of these floors and roofs is entirely owing to the pounding operation above described, as the same materials were tried in the ordinary way without success.

The writer has not had occasion to make use of this process in this climate, but gives a description, hoping that it may be of value to others who may have occasion to lay floors of lime in architectural or engineering works. He has never heard of this method being employed in this country; although it seems singular that it should be used so generally by a neighboring nation, and be wholly unknown to our builders.

APPENDIX.

The following correspondence, growing out of the above, is here printed:

From Estevan A. Fuertes, C. E., Member of the Society.

A paper read before the Society, upon a Mexican method of consolidating mortars, described as of extreme hardness, suggested to my mind that, perhaps, its author might be mistaken in attributing its main durability and hardness to the slow system of consolidating the road-bed and its cover.

My doubts have grown out of the circumstance that the author says (without seeming to attach much importance to the fact), that ochre or a similar pigment, was mixed with the mortar.

I think that the coloring matter, believed to be of secondary importance, is the main ingredient which determines the superiority of the cement described; and instead of its being ochre, it was underburnt brick dust.

If I am not the one who is mistaken, the consideration of this subject will bring up for discussion the method of obtaining a cheap and superior cement, that, I believe, has not been used much in this country.

The Hydraulic Engineer has much need of studying the causes which induce the "setting of mortars," because it is almost certain that the resistance of such materials as bricks, limes and cements, depends upon their conditions of crystallization.

I am aware of only two methods of hardening the silicates usually

employed in hydraulic works, viz., the gradual chemical change (crystallization in the slow, humid way, as in submerged foundations, etc.), and the quick vitrification under the influence of intense heat, as employed in brick-making.

It is notorious that under-burnt brick resists very badly the influence of atmospheric wear, especially near salt water. I have crumbled in my hand an under-burnt brick, one year after its exposure to the sea spray, and gunpowder was manufactured from the nitrate of potassa formed upon its porous substance; but the same clay burned with chalk, making a double salt of carbonate of lime and silicate of alumina, or rather a sub-crystalline double silicate of lime and alumina, after being ground, made a cement susceptible of receiving a splendid lustre, and withstood the action of the spray and of the waves without apparent change.

Both the limestone and the brick had been used separately as building material in a burying ground near the sea shore, where the experiments were conducted in 1861. Eighteen months of exposure for the stone and twelve months for the brick, were sufficient to render both materials useless; but when burnt, ground and mixed, they stood much better than the finest and distinctly crystalline marbles.

At the end of three years, or more than the sum of the times of durability of each material, I left the place where the experiments were made, and then the cement had not changed where the surface had been left rough, nor tarnished where it had been polished.

A cement called "Revocado" by Spanish Engineers is made by mixing in several proportions fat limes with sand and under-burnt brick dust. The usual proportions are measured by equal volumes of the three materials; but when the cement is to be used for stopping roof leaks, cementing cellars, or where blows upon the cement are not anticipated, the proportion of sand is greatly diminished, and even suppressed altogether.

The Spanish learned the compounding of this cement from the Biscayans probably; and I doubt if the Romans had anything to do with its introduction in Spain, because the ruins of ancient water channels with "revocado" exist in the Basque provinces, where neither Romans nor Moors ever penetrated. The Biscayans, in their turn, are the most ancient people with whom we are acquainted, it being probable that they preceded the Phœnicians.

I have seen Spanish "revocado" in Mexico, and it is natural to suppose that the Spaniards introduced the art in that country during the Conquest.

Now, may it not be possible that the ochre referred to by Gen. Ellis is only powdered brick, used to make the excellent and hard "revocado?"

The description given of the method of consolidating the mortar, etc., and even the employment of wooden compressors, explain accurately the process still followed in Spanish countries to form the floorings of plazas, public walks, etc.

In many cases, immediately before the cement becomes set, its surface is polished with a smooth cobble stone until it acquires a high and lasting lustre.

From Gen. Ellis, in reply to the above:

Having read the remarks of Mr. Fuertes upon my recent paper relating to hard lime floors, I apprehend that he did not give sufficient attention to the process therein described.

In no case was the red pigment mixed with the lime and sand, as he supposes, but was solely used for a surface coloring after the hardening process was completed. Roofs and sidewalks of equal hardness were also made by the same process of successive poundings without the coloring matter, and finished by polishing in the same manner as the colored floors.

The pigment used upon the floors was not brick dust, but a red earth found in the vicinity, probably a fine clay colored with sesquioxide of iron. Bricks were not used in that part of the country; "adobes" taking their place in building.

It will thus be seen that the material of which the described floors and roofs were made was not the same as the "revocado" used in Spain and Southern Mexico, described by Mr. Fuertes. Is not the term *revocado* essentially the same in meaning as the more common Castilian word *revoque*, one being the participle and the other the noun corresponding to the Spanish verb *revocar*, the nearest English equivalent to which, in an engineering sense, is to *rough cast*. This implies an admixture of coarse material in the mortar. "Revoque" was known to the Romans as "*parietis linimentum.*"

Mr. Fuertes, is, I think, in error when he attributes any rapidity of setting, greater hardness when set, or improved hydraulic qualities, to the mixture of burnt or underburnt brick in any proportions with lime. The experiments of Smeaton show conclusively that the only gain is the slight amount of moisture that the brick will absorb from the lime and favor its *drying*.

The only way in which hydraulic properties can be given to a compound of silicate of alumina and carbonate of lime is by burning them together after being mixed, as in the production of artificial cement. This is exactly what was done in the case Mr. Fuertes recounts; clay and chalk were burned together, and if in proper proportions would form an excellent artificial cement. It is not remarkable that neither should be a good building material by itself.

If the "revocado" of the Spanish possesses any quick setting or hydraulic qualities, it is probably not owing to the admixture of common brick, but to some qualities of the lime, or perhaps what Mr. Fuertes has taken to be brick was artificial "trass," formerly much used, which was burned like brick, and when added to mortar, gave it hydraulic properties.

I think it highly probable that the process of pounding ordinary lime mortar for many successive days in order to give it hardness, and afterwards polishing the surface, originally came from Spain to Mexico, and is probably an ancient practice. The only matter of surprise is that it has not become more generally known and used.

Note by the Printing Committee.

Is this "pounding process" of the Mexicans anything more than a simple yet effectual method of freeing the mortar of its *surplus water*, and thereby insuring a condition in which the lime can pass to a crystalline carbonate, at the same time compacting the whole mass into the best possible state?—*Vide* "Transactions" of this Society, No. X.

A Chemical Experiment.—A very pretty experiment, the uses for which may be judged by our readers, can be arranged as follows: Dissolve about 500 grains of nitrate of lead in six fluid-ounces of water, permit the same to stand until any turbidity may have subsided, and decant off the clear supernatant liquid, or, if convenient, filter the solution. Place the last in the position where it is intended it shall remain, and drop into it a few long, fibrous particles of sal ammoniac. Small crystals of chloride of lead begin to form, and ascend through the liquid, presenting the appearance of an ascending snow storm. When the lead is all precipitated the crystals of chloride begin to descend, forming, in their descent, grotesque masses resembling a winter landscape. If the vessel containing the reagents is not disturbed, it often presents its beauty for a week or two.

Chemistry, Physics, Technology, etc.

COMBUSTION IN COMPRESSED AIR.

By F. Collingwood, C. E.

Read before the Lyceum of Natural History, New York, Feb. 10, 1873.

In bringing up this subject at the present time, I do not know that I can offer any positive results; it is done rather with the hope that the discussion which may ensue may help to harmonize those which appear to be conflicting.

The observations made in the St. Louis caisson were at first reported as showing a decided increase in energy and amount of combustion as the air-pressure was increased. Quite recently, however, in the Franklin Institute "Journal," the statement is made that this was a mistake, and that there was *no* increase.

In the caissons of the East River bridge there was an admirable opportunity to test the question; but the engineers considered the fact that there *was* practically an increase to be a settled one, and the only facts they have, therefore, bearing upon the question were incidentally obtained while experimenting in another direction.

The fact of *imperfect* combustion of candles and other hydro-carbons when in compressed air was universally acknowledged, and the great annoyance from the smoke caused thereby, very early in the progress of the work, led to experiments with a view of removing, or at least alleviating the nuisance.

The first experiments were made with great care by Col. W. H. Paine. He tried various oils, common candles, and the *adamantine* candles, so called, of the size known as coach candles. The latter are composed of stearin, and are quite uniform in manufacture. They are $1\frac{1}{4}$ inch in diameter, and weigh three to the pound.

No *measurement* was made of the oils consumed; but at only eight pounds pressure above the atmosphere he noticed a very decided increase in the amount.

Of the two kinds of candles the results compared very closely, but as he recorded only the figures taken in connection with the coach candles, these remarks are necessarily restricted to them.

The elements noted were pressures of the air in the caisson (that above being taken at 15 lbs.), temperatures and quantities. In determining quantities, the lengths burned in a given time were noted, and the average of a number of experiments was taken. From these the

time required to burn a pound was deduced, and from this in turn the relative consumption as compared with that in open air of the same temperature.

The results obtained, when tabulated, are as follows:

No. of Experiment.	Absolute Pressure.	Time of burning 1 lb. of candles.	Relative Consumption.	Temperature.	Square root of Pressure.	Ratios of square roots of Pressure.
1	Open air = 15 lbs.	32 hours	1·	80°	3·873	1·
2	23	27	1·185+	80°	4·796	1·239
3	25	25½	1·255—	80°	5·000	1·291
4	Open air = 15	28	1·	88°	3·873	1·
5	46	16	1·75	88°	6·782	1·751

Candles carried about, at the time of experiment No. 2 (the pressure being 8 pounds above the atmosphere) would burn at the rate of a pound in 18 hours, and in a still less time when the pressure was increased. This shows a waste of one-third from flaring of the flame when in motion.

The effect of increased temperature in the open air is shown by experiments 1 and 4, although these were made with different lots of candles.

Comparing experiments 4 and 5 shows an increase in consumption of 75 per cent. by increasing the pressure of the air to three atmospheres.

Comparing 1 and 3 shows an increase of about 18 per cent. in consumption for 50 per cent. increase of pressure.

Unfortunately, the series of experiments is too incomplete to allow the establishment of a law of increase; but I found by trial that the ratio given in the 4th column compared quite closely with that given in the 7th. In other words, the amount of consumption at various pressures is *approximately*, at least, as the square roots of those pressures.

Independent of theoretical considerations, this result is of value as a practical fact, which gives a ready rule for determining the amount of supplies needed in any similar case. It would have been of great value to us as a check upon "stealage" and waste, had we known it in advance.

Whether more refined experiments may prove the opposite of these results to be true, such facts as those which follow were certainly matters of common observation, viz., the instant relighting of a candle when blown out, for a *number* of times in succession (in the St. Louis caisson it was done 20 times); the quick ignition of even a woolen

garment, if brought momentarily in contact with a flame; a cigar bursting into a flame in ordinary smoking (although, as the engineers were not smokers, they have this from hearsay only).

The question will next be asked, what precautions were taken against error in these observations?

1st. Differences of temperature, above and below, were carefully guarded against.

2d. Air-currents were entirely prevented, the tests being made in the centre of a chamber, 100×26 feet, in which at the time no work was progressing, and the air supply was at least 20 feet away.

3d. Impurity of the air was impossible. The total air space in the chamber was at least 130,000 cubic feet, and the air was entirely changed at least once every $1\frac{1}{2}$ hour, and often in less time.

4th. Lack of homogeneity of materials. This was guarded against as far as possible by always taking candles from the same boxes.

5th. Possible effects of excess of moisture in the air of caissons. This could not be prevented. The precess of condensation develops so much heat, that a spray of water has to be thrown into each air compressor constantly, to prevent heating of the machinery.

6th. It is submitted as a suggestion, whether a test by "standard" candles, owing to the fineness of the wick, might not lead to error, from the fact that the *capacity* of the *wick* is not increased by pressure. The only experiments made with these were by Prof. Seely, who reports but about 5 per cent. increase of consumption at 46 lbs. pressure, and attributes the discrepancy to this cause.

An experiment made with alcohol at the same pressure and 88° temperature, tends to confirm this view. The lamp had a loose cotton wick, $\frac{1}{4}''$ in diameter, and burned in the caisson *six* cubic inches per hour, and in the open air *two* cubic inches. Here we have, then, standard candles increasing 5 per ct. only; stearine candles, with wicks not so nicely adjusted, increasing 75 per cent.; and *alcohol*, the most limpid of all and most readily carried by capillary attraction, increasing 200 per cent. It will be noted that in the latter case the consumption was almost directly proportional to the pressures.

Another difference noted in the case of alcohol was that the flame in the caisson was entirely changed in appearance; being no longer blue, but of a white color, giving about three-fourths as much light as a coach candle.

Unfortunately, on comparing the cost of candles and alcohol, making full allowance for waste, the latter was found to be at least twice as great as the former. It is quite probable that a slight carboniz in

of the flame would have increased the light, thus diminishing cost without causing smoke, the amount of carbonizing being graduated to suit the pressure.

A serious objection might arise, however, from the possible danger of using so inflammable a substance in a confined space.

As a final resort for light in both caissons the street gas was introduced, and, to guard against accident from explosion, it was made one man's constant duty on every watch to attend to its lighting, regulating, turning off, &c. This did admirable service in the Brooklyn caisson, where the pressures were light; but in the New York caisson, after reaching about 20 pounds pressure above the atmosphere, the gas-lights began to smoke fearfully.

Following up the idea, that the cause of the smoke was a lack of *ventilation* of the flame—in other words, of circulation of the air around it—it occurred to me that if the gas could be spread more, or thrown out in a thinner sheet, the light would be improved. For this purpose the *size* of the burners was reduced from a six-foot fish-tail to a two-foot bat-wing, of the kind known as the "excavated tip." The result was entire freedom (for the time) from smoke, less gas burned, and a better light. At about 28 pounds pressure above atmosphere these smoked badly, and were exchanged for one-foot burners of the same pattern. The latter answered a good purpose up to the close of the work.

In this experience there arises an incidental proof of the fact that the energy of combustion was increased, which is this:

The excess of pressure at the burners under which the gas was consumed was fully two inches of water, and I am informed that it would be *impossible* to get *any* light from a burner in the open air under such pressure, one-half inch being the best pressure in most cases. An argand burner gives the best light at only fifteen-hundredths of an inch pressure. At any less than two inches in the caisson, however, the light was poor, and at half an inch the lights would go out.

This measurement was made near the centre of the caisson, but I am satisfied that many of the lights burned at still *higher* pressures.

This completes the record and discussion of experiments; and it remains only to be shown that when a flame is exposed to pressure its relations to the surrounding air are essentially changed, and that we might reasonably expect a change in the energy of combustion.

Turn a moment, if you please, to the fundamental relations of magnitude, viz., *volume, surface, linear dimensions. Volumes*, in bodies

of similar form, are said to vary as the *cubes* of similar lines, and *surfaces* of the same bodies as the *squares* of the same lines.

Suppose, then, we have volumes (flames, if you please) having diameters 1, 2, 3, 4. Their surfaces will be as 1, 4, 9, 16, and their *volumes* as 1, 8, 27, 64.

Manifestly, then, if we diminish a volume, we by no means diminish the corresponding surface in the same ratio. A volume one-half the size of 64 would be 32, but its *surface* would be considerably more than half of 16; and in order to obtain it, we must multiply 16 by the square of the cube root of $\frac{1}{2}$.

Turn next to the consideration of flame itself. In ordinary combustion for purposes of illumination a hydro-carbon in the form of liquid is carried up along a wick by capillary attraction. Meeting the point where combustion is progressing it is distilled. The gases and vapors evolved have a tension exactly equal to that of the surrounding air. If the temperature of the flame be increased, with *no* increase of combustion, the flame would tend to expand in size. If the pressure of the air be *diminished* the flame would tend to expand also. On the contrary, if temperature be diminished and pressure increased the flame would *diminish* in size.

Again: if the flame be diminished in size by condensation, supposing *no* increase in combustion, the temperature will necessarily increase, from the simple fact of condensation. In every case, therefore, there will be somewhere a balance between these opposing tendencies.

But we have not yet decided the cause of the flame assuming primarily any specific volume. This manifestly will be reached when the flame has expanded sufficiently to allow the chemical combination of its distilled gases with the oxygen of the air to progress at its surface as rapidly as these gases are distilled by the heat of the flame.

Now, to apply these principles, let us prepare a table as follows, using the pressures noted in the previous table:

Absolute pressures.	Volumes of gases by Marriotte's law.	Surfaces. Deduced by taking $\frac{2}{3}$ power of the volumes.	Ratios of surfaces to corresponding volumes.
15	$1 = 1\cdot$	1·	1·
23	$\frac{15}{23} = 0\cdot652$	0·752	1·153
25	$\frac{15}{25} = 0\cdot6$	0·711	1·185
46	$\frac{15}{46} = 0\cdot326$	0·474	1·453

The law that under a constant temperature the volumes of gases vary inversely as their pressures, gives at once the second column from the first, for the volume of the same quantity of gas under the different pressures named.

If these various volumes have similar forms, as in the case of a flame, then manifestly they will have *surfaces* as in the third column.

Taking next the ratio of each surface to its corresponding volume, we get the fourth column, and we have arrived at this result:

That the surface of a flame, in proportion to its volume, will be nearly half greater under three atmospheres of pressure than under one; this being under the condition of an invariable temperature, and supposing that no other considerations modify the result.

Admitting these suppositions, and remembering that every part of this additional surface is three times as rich in oxygen, it is at once evident that the facility for the chemical forces to act is increased; and we would expect increased energy of combustion, increased temperature, and *consequently* an increase of distillation and consumption of material.

Some of the modifying considerations are as follows:

Loss of heat by radiation and convection, nitrogen also being present in increased proportion.

The varying rapidity with which the various substances—wax, alcohol, &c.—will be carried by a wick.

A technical point may be made, also, as to whether carbon passing off as lampblack can be said to be consumed. As to this, it is sufficient to say that it *is* consumed, from the practical point of view, at least it has to be paid for.

It is with much hesitation that the views expressed in this paper have been advanced, more especially as the author has not the leisure necessary to give them careful thought, or to make farther experiments.

They may be proven to be entirely erroneous, but he trusts they may help in some degree to a clearer knowledge of the subject discussed.

ON SYMPATHETIC VIBRATIONS, AS EXHIBITED IN ORDINARY MACHINERY.

BY JOSEPH LOVERING, of Cambridge, Mass.

At the meeting of this Association in Burlington, I showed some experiments in illustration of the *optical method* of making sensible the vibrations of the column of air in an organ-pipe. At the Chicago meeting, I demonstrated the way in which the vibrations of strings could be studied by the eye in place of the ear, when these strings were attached to tuning-forks with which they could vibrate in sympathy; substituting for the small forks, originally used by Melde, a colossal tuning fork, the prongs of which were placed between the poles of a powerful electro-magnet. This fork, which interrupted the battery current, at the proper time, by its own motion, was able to put a heavy cord, thirty feet in length, in the most energetic vibration, and for an indefinite time. I propose, at the present time, to speak of those sympathetic vibrations which are pitched so low as not to come within the limits of human ears, but which are felt rather than heard, and to show how they may be seen as well as felt.

All structures, large or small, simple or complex, have a definite rate of vibration, depending on their materials, size and shape, and as fixed as the fundamental note of a musical cord. They may also vibrate *in parts*, as the cord does, and thus be capable of various increasing rates of vibration, which constitute their harmonics. If one body vibrates, all others in the neighborhood will respond, if the rate of vibration in the first agrees with their own principal or secondary rates of vibration, even when no more substantial bond than the air unites a body with its neighbors. In this way, mechanical disturbances, harmless in their origin, assume a troublesome and perhaps a dangerous character, when they enter bodies all too ready to move at the required rate, and sometimes beyond the sphere of their stability.

When the bridge at Colebrooke Dale (the first iron bridge in the world) was building, a fiddler came along and said to the workmen that he could fiddle their bridge down. The builders thought this boast a fiddle-de-dee, and invited the itinerant musician to fiddle away to his heart's content. One note after another was struck upon the strings until one was found with which the bridge was in sympathy. When the bridge began to shake violently, the incredulous workmen were alarmed at the unexpected result, and ordered the fiddler to stop.

At one time, considerable annoyance was experienced in one of the mills in Lowell, because the walls of the building and the floors were violently shaken by the machinery; so much so that, on certain days, a pail of water would be nearly emptied of its contents, while on other days all was quiet. Upon investigation it appeared that the building shook in response to the motion of the machinery only when that moved at a particular rate, coinciding with one of the harmonics of the structure; and the simple remedy for the trouble consisted in making the machinery move at a little more or a little less speed, so as to put it out of time with the building.

We can easily believe that, in many cases, these violent vibrations will loosen the cement and derange the parts of a building, so that it may afterwards fall under the pressure of a weight which otherwise it was fully able to bear, and at a time, possibly, when the machinery is not in motion; and this may have something to do with such accidents as that which happened to the Pemberton mills in Lawrence. Large trees are uprooted in powerful gales, because the wind comes in gusts; and if these gusts happen to be timed in accordance with the natural swing of the tree, the effect is irresistible. The slow vibrations which proceed from the largest pipes of a large organ, and which are below the range of musical sounds, are able to shake the walls and floors of a building so as to be felt, if not heard, thereby furnishing a background of noise on which the true musical sounds may be projected.

We have here the reason of the rule observed by marching armies when they cross a bridge, viz., to stop the music, break step and open column, lest the measured cadence of a condensed mass of men should urge the bridge to vibrate beyond its sphere of cohesion. A neglect of this rule has led to serious accidents. The Broughton bridge, near Manchester, gave way beneath the measured tread of only sixty men who were marching over it. The celebrated engineer, Robert Stephenson, has remarked* that there is not so much danger to a bridge, when it is crowded with men or cattle, or if cavalry are passing over it, as when men go over it in marching order. A chain-bridge crosses the river Dordogne on the road to Bordeaux. One of the Stephensons passed over it in 1845, and was so much struck with its defects, although it had been recently erected, that he notified the authorities in regard to them. A few years afterwards it gave way when troops were marching over it.†

* Edin. Phil. Journ., v, p. 255.

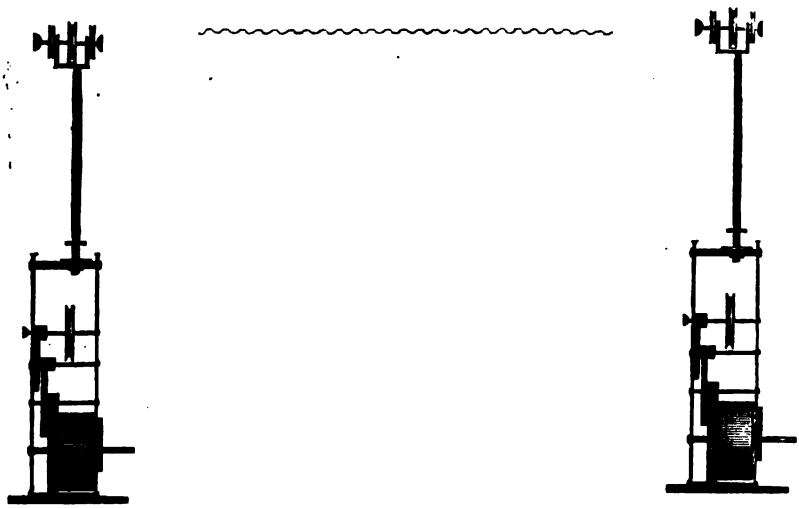
† Smith's Life of Stephenson, p. 390.

A few years ago, a terrible disaster befel a battalion of French infantry while crossing the suspension bridge at Angiers, in France. Reiterated warnings were given to the troops to break into sections, as is usually done. But the rain was falling heavily, and, in the hurry of the moment, the orders were disregarded. The bridge, which was only twelve years old, and which had been repaired the year before at a cost of $7000, fell, and two hundred and eighty dead bodies were found, besides many who were wounded. Among the killed or drowned were the chief of battallion and four other officers. Many of the guns were bent double, and one musket pierced completely through the body of a soldier. The wholesale slaughter at the bridge of Beresina, in Russia, when Napoleon was retreating from Moscow, in 1812, and his troops crowded upon the bridge and broke it, furnishes a fitting parallel to this great calamity.

When Galileo set a pendulum in strong vibration by blowing on it whenever it was moving away from his mouth, he gave a good illustration of the way in which small but regularly repeated disturbances grow into consequence. Tyndall tells us that the Swiss muleteers tie up the bells of the mules, for fear that the tinkle should bring an avalanche down. The breaking of a drinking-glass by the human voice, when its fundamental note is sounded, is a well-authenticated feat; and Chladni mentions an innkeeper who frequently repeated the experiment for the entertainment of his guests and his own profit. The nightingale is said to kill by the power of its notes. The bark of a dog is able to call forth a response from certain strings of the piano. And a curious passage has been pointed out in the Talmud, which discusses the indemnity to be claimed when a vessel is broken by the voice of a domestic animal. If we enter the domain of music, there is no end to the illustrations which might be given of these sympathetic vibrations. They play a conspicuous part in most musical instruments, and the sounds which these instruments produce would be meagre and ineffective without them.

In the case of vibrations which are simply mechanical, without being audible, or at any rate musical, the following ocular demonstration may be given. A train of wheels, set in motion by a strong spring wound up in a drum, causes a horizontal spindle to revolve with great velocity. Two pieces of apparatus like this are placed at the opposite sides of a room. On the ends of the spindles which face one another are attached buttons about an inch in diameter. The two ends of a piece of white tape are fastened to the rims of these buttons.

When the spindles, with the attached buttons, revolve, the two ends of the tape revolve, and in such directions as to prevent the tape from twisting, unless the velocities are different. Even if the two trains of wheels move with unequal velocities, when independent of each



other, the motions tend to uniformity when the two spindles are connected by the tape. Now, by moving slightly the apparatus at one end of the room, the tape may be tightened or loosened. If the tape is tightened, its rate of vibration is increased, and, at the same time, the velocity of the spindles is diminished on account of the greater resistance. If the tape is slackened, its rate of vibration is less, and the velocity of the spindles is greater. By this change we can readily bring the fundamental vibration of the tape into unison with the machinery, and then the tape responds by a vibration of great amplitude, visible to all beholders. If we begin gradually to loosen the tape, it soon ceases to respond, on account of the twofold effect already described, until the time comes when the velocity of the machinery accords with the first harmonic of the tape, and the latter divides beautifully into two vibrating segments with a node at the middle. As the tension slowly diminishes, the different harmonics are successively developed, until finally the tape is broken up into numerous segments only an inch or two in length. The eye is as much delighted by this visible music as the ear could be if the vibrations were audible; and the optical demonstration has this advantage,

that all may see, while few have musical ears. A tape is preferred to a cord in this experiment, because it is better seen, and any accidental twist it may acquire is less troublesome. The wood-cuts on the opposite page represent the apparatus used, drawn on a scale of one inch to five inches.

SOME PARTICULARS IN RELATION TO COTTON AND COTTON MANUFACTURES, CHRONOLOGICALLY ARRANGED.*

By Mr. Samuel Batchelder.

The earliest patent granted in Great Britain for any important improvement in manufacturing was that to John Kay, for the invention of the fly shuttle, May 26, ... 1733

The first machinery for spinning, of which we have any satisfactory account, was that invented by John Wyatt, soon after 1730, and which was patented in the name of Lewis Paul, June 24, ... 1738

A patent for carding machinery, in which is described the cylinder card, as first used by hand, was granted to Lewis Paul, August 30, ... 1748

A second patent for spinning machinery was granted to Lewis Paul, June 29, ... 1758

The invention of the drop-box by Robert Kay, by means of which filling of different colors could be used with the fly-shuttle, ... 1760

According to Guest, the spinning-jenny was invented by Thomas Highs, ... 1764

The invention is also claimed by James Hargraves, who took a patent for it, June 12, ... 1770

Arkwright's first patent for spinning machinery, July 3, . 1769

Act of Parliament to prohibit the exportation of machinery, 1774

Second patent to Arkwright, including Carding, Drawing and Spinning, was granted December 16, ... 1775

Patent to Robert Peele, for Carding, Roving and Spinning, February 18, ... 1779

Mule spinning invented by Samuel Crompton (not patented) 1779

James Watt took his first patents for improvements in steam engine, March 12, ... 1782

Subsequent patents in 1784 and 1785.

* From the Bulletin of the National Association of Wool Manufacturers.

Power-loom invented by Edmund Cartwright, first patent, April 4, ... 1785

Subsequent patents, 1786, 1787, 1788.

Arkwright's patents declared void, ... 1785

Cylinder printing was patented by Thomas Bell, July 17, 1783, and introduced in Lancashire, ... 1785

Bleaching by oxymuriatic acid was discovered in France by Berthollet, ... 1785

And introduced at Manchester practically 1788

Legislature of Massachusetts made a grant to Robert and Alexander Barr to aid them in building machinery for spinning cotton, ... 1786

First machinery for spinning cotton put in operation in France, ... 1787

Grant to Thomas Somers by the Legislature of Massachusetts, to aid him in completing machines for spinning, . . 1787

First cotton factory built in the United States at Beverly, Massachusetts, ... 1787

Some spinning-jennies were put in operation in Philadelphia and Providence, ... 1788

Commencement of the cultivation of Sea Island cotton in Georgia, from Pernambuco seed, ... 1789

Samuel Slater came to this country, and was employed at New York, where he said they had in operation one carding engine and two spinning-jennies, at the close of the year, . 1789

Slater came to Providence, Rhode Island, and began building a cotton factory, ... 1790

In which they commenced spinning early in 1791

Cotton gin invented by Eli Whitney in 1793, and patented March 14, ... 1794

Cotton mill built by Slater and others at Pawtucket, Massachusetts, ... 1798

First cotton mill and machinery in Switzerland, . . . 1798

First spinning machinery in Saxony, ... 1799

Water-mill at Beverly, Massachusetts, with Arkwright machinery, ... 1802

First cotton mill in New Hampshire commenced at New Ipswich in 1803, and went into operation : 1804

Second mill at Pawtucket, Massachusetts, ... 1805

Mill at Pomfret, Connecticut, ... 1806

After the patents for a power-loom to Edmund Cartwright, several other patents were taken by other parties, some of which went into partial operation, but none with any success, until the invention of the dressing-frame by Radcliff and Ross, with the assistance of Thomas Johnson. Guest gives the date of this invention 1803, Baines in 1804. One of the patents to Thomas Johnson was issued Feb. 28, 1803, and another June 2, 1804; and a mill for weaving was built at Manchester in 1806, which may be considered the date of the successful commencement of power-loom weaving, . . 1806

Mill built at Smithfield, Rhode Island, by John Slater, . 1807

Mill built at Watertown, Massachusetts, ... 1807

Second cotton mill in New Hampihire at New Ipswich, . 1808

Norfolk cotton factory at Dedham, incorporated, . . 1808

First cotton mill in Maine, at Brunswick, . . . 1809

Mill at Dorchester, Massachusetts, incorporated, . . 1811

Incorporation of Boston Manufacturing Company, known as *Waltham Company*, ... 1813

Power-looms in operation at Waltham, being the first in the United States, ... 1814

William Gilmore emigrated to this country, . . . 1815

And put the crank-loom in operation in Rhode Island, . . 1817

First cotton factory built at Lowell, ... 1822

Self-acting mule patented by Richard Roberts, March 29, . 1825

First cotton mill at Lawrence, Massachusetts, . . . 1849

There is so much uncertainty and inaccuracy as to the dates of many improvements and inventions in cotton machinery in the accounts given by Guest, Kennedy, Baines and others, who seem to have copied one another's errors, instead of correcting them, that I have referred for the dates of all patented improvements to the collection of "Specifications of Inventions from March 2, 1617, to October 1, 1852," in Great Britain, contained one hundred and sixty volumes of text, and three hundred and ten volumes of plates, a copy of which may be found in the Boston Library.

SOME PARTICULARS IN RELATION TO WOOL AND WOOLEN MANUFACTURES, CHRONOLOGICALLY ARRANGED.*

By Editor of Bulletin of N. A. W. M.

The export of wool from England, first prohibited in the reign of Edward III, ... 1337

The stocking-frame, invented by William Lea, ... 1585

Sheep introduced at Jamestown, Virginia, ... 1609

And first brought to Boston in 1633

The first fulling-mill erected at Rowley, Massachusetts, by "Mr. Roger's people, who were the first that set upon making cloth in this Western world," 1643

Exportation of wool from England definitely prohibited, . 1660

Which prohibition continued until 1825

The fly-shuttle first used by woolen weavers, and used very little by weavers of cotton until 1760, invented by John Kay, 1733

The first ram let by Mr. Bakewell, the improver of the English Leicester sheep, in 1760

Spanish merino sheep introduced into Saxony by the Elector, ... 1765

Merinos introduced into Hungary by Maria Theresa, . 1775

Merinos imported from Spain to France, ... 1776

A French manufacturer announced that he had carded wool with success on a cotton carding-machine in 1783

The first machine for spinning wool was tried at Dolphin Holme, England, ... 1784

Merinos introduced at Rambouillet, France, by Daubenton, in 1786

The first woolen factory established and conducted advantageously in America, erected in that portion of Newbury, Massachusetts, known as Byfield Parish, ... 1714

The first carding-machine for wool put in operation in the United States, constructed under the supervision of John and Arthur Schofield, ... 1794

Carding-machine erected by Arthur Schofield, at Pittsfield, Massachusetts, ... 1800

The fabric called French merino, introduced by Dauphinot Pallotan, at Rheims, France, ... 1801

The first merinos known to have left full-blood descendants,

* From the Bulletin of the National Association of Wool Manufacturers.

introduced to United States by Col. Humphreys, the American minister to Spain, on his return from his embassy, in . 1802

Gray mixed broadcloth made at Pittsfield, and sold in New York as foreign, ... 1804

Importations by Wm. Jarvis of nearly 4,000 merinos, 1809 to 1810

The first bale of wool came to England from Australia in . 1810

Card clothing machine invented by Elijah Smith, of Walpole Mass., and patented by Whittemore, ... 1810

The loom for weaving figured fabrics called Jaquard, invented by Joseph Maria Jaquard in 1811

Machine for shearing cloth, called a machine with helicoidal shears, introduced into France by George Bass, of Boston, in 1812

The largest manufactory of fine cloths in New England, the Middletown Manuf. Co., made daily 30 to 40 yards of broadcloth, which sold by the piece at $9 to $10 per yard, in . 1812

Shoddy first introduced at Batley, England, about . . 1813

The Pittsfield Wool Manufacturing Company, Lemuel Pomeroy & Co., incorporated, ... 1814

The Glenham Wool Manufacturing Company Mill erected in Dutchess County, New York 1814

The principle of helicoidal shears, introduced by Bass, adopted by Collier, of Paris, in 1817

Saxony merinos introduced into United States under impulse of wool tariff, maintaining an almost undisputed ascendancy for about fifteen years, ... 1824

Mousselines de laine made a fine wool for printing, introduced at Troixville, France, ... 1826

The invention of William Goulding, dispensing with the billy and obtaining the endless roll, patented 1826

The knitting-frame first operated by power at Cohoes, New York, by Egbert Egberts, ... 1832

Mousseline de laine with cotton warps introduced in France, 1833

Fancy cassimeres invented by Bonjean at Sedan, France, . 1834

Machine for burring wool invented, and first successfully used by Michael H. Simpson, of Boston, Mass., ... 1834

The manufacture of shoddy from felted cloths, first undertaken on a grand scale at Batley, Yorkshire, ... 1840

Automatic weaving of ingrain carpets invented by E. B. Bigelow, of Boston, ... 1842

The mechanical comber for drawing out the fibre at both

ends of the lock of fibrous material, patented by Joshua Heilman, of France, ... 1845

Silesian merinos introduced in the United States by William Chamberlain, ... 1851

Circular knitting-machine invented by John Pepper, . . 1851

The first Mousselines de laine made at the Pacific Mills, Lawrence, Massachusetts, ... 1853

Wool-comber used for carpet-wools invented by Michael H. Simpson, ... 1854

Impulse given to the worsted industry of the United States by the Reciprocity Treaty of 1854

Aniline dyes introduced commercially by Perkins in . . 1857

Plain bareges for printing, introduced, ... 1858

Worsted braids first made in United States in . . . 1860

National Association of Wool Manufacturers founded, . 1864

National Wool Growers Association founded, . . . 1865

Alliance between the Wool Growers and Wool Manufacturers of United States established at Syracuse Convention of December 13, ... 1865

Wool and woolen tariff founded on joint recommendation of wool growers and wool manufacturers, ... 1867

Copper for Gas-Pipes.—The employment of gas-pipes constructed of copper or bronze has occasionally led to serious accidents from the explosion of the cupro-acetylene which is formed in them by the action of the acetylene contained in the gas on the copper.

The acetylene is one of the impurities of ordinary coal-gas, though it can be obtained in larger quantity by lowering a Bunsen burner until it retreats to the base of the lamp, and then leading the products obtained into an ammoniacal solution of cuprous chloride. Acetylene mixed with air, and in presence of moisture, rapidly attacks metallic copper, and the metal becomes covered with a black deposit, which explodes violently when heated.

This compound is readily decomposed by hydrochloric acid, and the suggestion is made* that, by occasionally filling such pipes with this acid, permitting them to remain thus filled for a few minutes, and then washing out with hot water, the dangerous compound which may have accumulated by the long-continued action of illuminating gas may be effectually removed.

THE BOYDEN PREMIUM.

URIAH A. BOYDEN, ESQ., of Boston, Mass., has deposited with the Franklin Institute the sum of one thousand dollars, to be awarded as a premium to

"Any resident of North America who shall determine by experiment whether all rays of light, and other physical rays, are or are not transmitted with the same velocity."

The following conditions have been established for the award of the premium:

1. Any resident of North America, or of the West India Islands, may be a competitor for the premium; the southern boundary of Mexico being considered as the southern limit of North America.

2. Each competitor must transmit to the Secretary of the Franklin Institute a memoir, describing in detail the apparatus, the mode of experimenting, and the results; and all memoirs received by him before the first day of January one thousand eight hundred and seventy-three, will, as soon as possible after this date, be transmitted to the Committee of Judges.

3. The Board of Managers of the Franklin Institute shall, before the first day of January, one thousand eight hundred and seventy three, select three citizens of the United States, of competent scientific ability, to whom the memoir shall be referred; and the said Judges shall examine the memoirs and report to the Franklin Institute whether, in their opinion, and, if so, which of their memoirs is worthy of the premium. And, on their report, the Franklin Institute shall decide whether the premium shall be awarded as recommended by the Judges.

4. Every memoir shall be anonymous, but shall contain some motto or sign by which it can be recognized and designated, and shall be accompanied by a sealed envelope, endorsed on the outside with same motto or sign, and containing the name and address of the author of the memoir. It shall be the duty of the Secretary of the Franklin Institute to keep these envelopes securely and unopened until the Judges shall have finished their examination; when, should the Judges be of opinion that any one of the memoirs is worthy of the premium, the corresponding envelope shall be opened, and the name of the author communicated to the Institute.

5. Should the Judges think proper, they may require the experiments described in any of the memoirs to be repeated in their presence.

6. The memoirs presented for the premium shall become the property of the Franklin Institute, and shall be published as it may direct.

Contents for May, 1873.

Illustrations—One Plate and Nine Woodcuts.

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EDITORIAL.

ITEMS AND NOVELTIES.

The Girard Avenue Bridge, Philadelphia.—We present herewith a well-executed engraving, from Messrs. Van Ingen & Snyder, of this city, representing a view of the new bridge over the Schuylkill at Girard avenue, which will, when completed, form the chief highway to that portion of Fairmount Park in which it is intended to place the buildings of the International Exposition of 1876.

For the following abstract of the details of the new structure we are indebted to the Pennsylvania Engineer and Manufacturer.

The Councils of the city of Philadelphia have decided that this bridge shall represent the highest level to which the art of iron bridge building has yet attained.

The contract for the work has been awarded to the Phœnix Iron Works, at Phœnixville, Pa.

It is decided that the bridge shall be 100 feet wide, which is stated to be wider than any bridge yet constructed. It allows of seven lines of carriages, driving abreast on the roadway, and has two lines of sidewalks about fifteen feet in the clear.

The widest bridges in Europe are the new Westminster and the new Waterloo bridges, at London, which are respectively eighty and eighty-five feet in width.

The design being that no perishable materials shall enter into the construction of the new bridge, it is specified that upon the iron floor joists shall be laid corrugated iron plates, and that these be covered with asphalt concrete, which, while forming a perfectly water-tight surface, shall yet be tolerably elastic. Upon this is to come a pavement of granite blocks laid in cement.

For each track there is designed to be a tramway, consisting of two lines of smooth flags, twelve inches wide, upon which the wheels of vehicles will run. The tramways are not to project above the general surface.

The sidewalk will consist of slate or flags, also laid in cement, and bordered with bright colored tiles. Between the sidewalks and the roadways will be placed iron railings of ornamental design, secured to the granite curbstone.

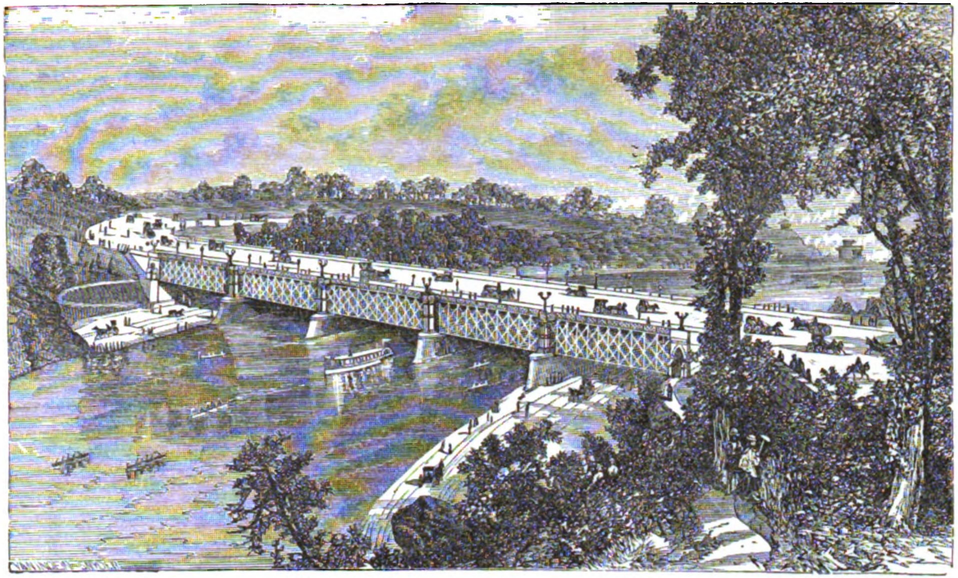
It is designed to make this structure architecturally as elegant as possible, in realizing which the work itself will be ornamented instead of applying constructed ornamentation.

The balustrade in the outer line of the sidewalks will have bronze panels worked with elaborate designs. There will be a richly ornamented cornice and frieze below this, about three feet and a half deep. The iron work of the supporting trusses will be picked out in colors and gold. The piers and abutments will be constructed of Maine granite. The dressed-work abutments will be constructed of such stone as will give contrast of color. There will be a margin or factor of safety of five times the strength required to sustain a fixed and moving load of three hundred pounds per square foot.

The upper chords and vertical posts will be made of Phœnix columns. The tension members of Phœnix weldless link bars. The bridge is to be completed within eighteen months.

American Railroad Master Mechanics Association.—The sixth annual convention of this body has just finished its sittings at Baltimore, Md. One hundred and thirty members were in attendance. Seventeen new members were received. Amongst other interesting business we have space to notice that the Committee on Boiler Incrustation was continued, and that Messrs. Coleman Sellers, of Philadelphia, and Peebles, of New Jersey, were added to it.

The subject of the chemical examination of waters used in locomotive boilers, and the comparative value of anthracite and bituminous coal and wood in generating steam, excited considerable discussion,



GIRARD AVENUE BRIDGE, PHILADELPHIA.

a report upon the latter subject being read before the meeting. Mr. W. W. Evans read a paper on the relative cost of operating roads of 3 feet 6 inches gauge or less, and those of 4 feet 8½ inches gauge.

In addition to this, reports were presented and discussed on construction, operation and cost of maintaining continuous train brakes and other related matters.

Report of the Working of Shaw's Water-Bearing on the Steamer Mary from Philadelphia to Providence, R. I.

May, 1873. Day of Month.	May, 1873. Hour.		Steam Pressure	Vacuum.	Water pressure on Water-Bearing.	No. of revolutions in 5 min. with Water-Bearing.	No. of revolutions in 5 min. with old Bearing.
May 10	9	P. M.	29	12½	16	370	
"	9·30	"	30	12½			368
"	9·40	"	30	12½	15½	385	
"	10	"	30	12½	15½	383	
"	10·15	"	30	12½			373
"	10·30	"	29	12½	18	380	
May 11	9	A. M.	30	12½	15½	385	
"	9·15	"	30	12½			380
"	11	"	27½	12½	15½	386	
"	11·15	"	27½	12½			373
"	4	P. M.	31	12½	15½	390	
"	4·15	"	30	13½			383
May 12	9	A. M.	32	12½	15½	408	
"	9·15	"	31	12½			373
"	9·30	"	31	12½			396
"	10	"	30½	12½	17	402	
						Average revolutions in 5 min·, 387·6.	Av'rge revs. in 5 min., 380.7.
						Av'rge steam and vacuum, 42.2.	Av'ge steam & vacuum, 42.4.

The area of water surface on Shaw's Bearing is 277·4 at maximum load 17 lbs. water pressure = 4·709 lbs. total end thrust.

The engine is 38 in. diam. × 34 in. stroke, with surface condenser. A superior working engine with adjustable cut-off set at 10 inches. Built by Neafie & Levy, of Philadelphia.

It is proper to remark that the thrust-bearing recently placed on shaft by Neafie & Levy is a very superior bearing, with new polished

and well oiled surfaces; otherwise the difference between the two bearings would be more prominent in point of revolutions.

The thickness of water in Shaw's Water Bearing is five inches, and it is upon this disc or slice of water that the entire load of end thrust is made to float; the metallic surfaces being five inches apart, there is no possible chance of the surfaces to reach each other to cause cutting or grinding, as in the ordinary plan; therefore one of Shaw's Bearing might be run for fifty years without even rubbing tool marks out, which, of course, will make considerable saving in the item of repairs.

Shaw's Water Bearing is a perfect dynanometer, indicating the actual power to propel the ship, the effect of which can always be noticed upon the gauge communicating with the water bearing.

It will be evident that the almost total absence of friction in Shaw's Water Bearing does away with all apprehension of heating the thrust-bearing—one of the greatest annoyances the engineer has to contend with.

JOSEPH L. PARRY, *Engineer.*

The New Bridge at Fairmount.—Work has already begun upon the new iron structure intended to replace the present, and once famous, wire structure across the Schuylkill, at Fairmount. The new bridge is arranged to have two roadways, one above the other. The east approach, for the upper roadway, will commence at Twenty-fifth street opposite to Spring Garden Street. It will pass alongside of the reservoir, and reach an elevation of thirty-two feet above Callowhill Street, at a point near to the entrance of Fairmount Park. There will be two towers of masonry at each end of the bridge, erected upon the present abutments. From the western end of the bridge to Thirtieth Street there will be an approach similar to the one on the east side, with a bridge at Thirtieth Street, having a clear span of 80 feet. From this point, for a distance of 140 feet, the upper roadway will be sustained by retaining walls, terminating at each end with abutments. There will be three spans of plate girders over the Pennsylvania Railroad.

From the Pennsylvania Railroad to Thirty-second Street the grade of the street as now used will be changed, so as to descend regularly, and cross the rails at an elevation of 24·8 feet. The lower roadway will commence on the east side at the angle in Callowhill Street, upon the level as now in use, passing under the colonnade upon a level approximating to the present roadway to Thirtieth Street.

The bridge, of the truss pattern, will be 348 feet from centre to centre of end ports, and 34 feet high from lower to top chord.

The upper roadway will be 50 feet wide with a carriage way of 32 feet, and an 8 foot footway on each side. The lower roadway will be 27 feet, with footways varying from 12 to 15½ feet in width. The weight of the iron structure will be 5½ tons per lineal foot. The bridge is expected to be completed in 1874.

A New Water Tunnel for Chicago.—The capacity of the water works of the city of Chicago, about 54,000,000 gallons, has been found insufficient to meet the wants of its growing community, in consequence of which an enlargement of the same has been determined on and is now in course of completion.

It will be remembered that the city is supplied from Lake Michigan, by means of a tunnel beneath its bottom—extending out about two miles into the lake. To meet the growing demand for greater supply, contracts for the construction of another tunnel have been made, and the work is now in operation. The new tunnel is to be seven feet in diameter and six miles in length, of which four miles extend beneath the city and two beneath the lake.

The New York *Times* contains the information that "the laborers on the shore end have progressed some 2000 feet out under the lake, while from the crib end another body of men are working forward to meet them. The limited diameter of the bore renders it impossible for many to work at once, but the work is pressed forward night and day, averaging at each end perhaps twelve feet in twenty-four hours. The masons keep as close behind the diggers as possible. The soil penetrated is a hard blue clay, and such a thing as a caving in has not happened thus far. A tin tube, eight inches in diameter, is constantly advanced with the workmen, thus furnishing a circulation which prevents the accumulation of foul air.

"The new tunnel runs parallel with the old one, distant from it about fifty feet. It will deliver its supply at the new works, at the corner of Ashland and Blue Island Avenues, three and five-sixths miles from the old ones; and to reach it the new tunnel is to be extended under the city, river, large business houses and all. It is estimated that the cost will be somewhere in the neighborhood of $1,000,000." * * * * * *

The land tunnel as well as its lake connection is to have a vertical diameter in the clear of seven feet two inches, and a horizontal di-

ameter of seven feet. Its capacity will be over 100,000,000 gallons per day. It will be lined with heavy masonry a foot thick, and of the best materials. January 1st, 1875, is specified as the date of its completion.

American Association for the Advancement of Science.—We have received the annual circular of this National Association, from which we learn that its twenty-second annual meeting will be held in Portland, Maine; commencing Wednesday, August 26th.

The officers of the coming meeting are: President, Joseph Lovering, of Cambridge, Mass.; Vice-President, A. H. Worthen, of Springfield, Ill.; General Secretary, C. A. White, of Iowa City, Iowa; Treasurer, Wm. S. Vaux, of Philadelphia, Pa.; Permanent Secretary, F. W. Putnam, of Salem, Mass. Standing Committee, J. Lawrence Smith, of Louisville, Ky.; Alexander Winchell, of Syracuse, N. Y.; E. S. Morse, of Salem, Mass., together with the officers of this meeting, already named. As the Local Committee appears to be an energetic one, the coming meeting promises to be one of more than ordinary interest.

Improvement in Manufacture of Coal Gas.—The process of Mr. Eveleigh, which is at present attracting considerable attention abroad, consists in, 1st, Distilling the coal destructively at a comparatively low temperature; 2d, Producing a gas rich in heavy hydro-carbons by the distillation of the oil and tar resulting from the first distillation. It is claimed that by this process, while the working expenses of the works are not materially increased, the quantity and quality of the gas and coke are decidedly increased. Experiments carried out by Dr. Letheby on the gas manufactured by this process showed that it afforded, on an average, a light equivalent to 23 05 candles; though the sulphurous and ammoniacal impurities were relatively considerable.

The Gas-Light Association of the U. S.—We learn through Professor Henry Wurtz, editor of *Am. Gas-Light Journal*, of the recent organization of a National Association of the American Gas Fraternity.

The need of such a union for promoting the development of this important interest, in its scientific and commercial aspects, has long been felt, and earnest and repeated efforts have been put forth to bring about the important movement, of which it is our pleasure to

announce the inauguration. It is to be wished that it may prove as beneficial in its working to all interested as the numerous kindred associations abroad, and it is to be hoped will mark a new era in the history of gas in America.

The following gentlemen have been elected officers of the new Association:—President, Chas. Roome, N. Y., president Manhattan Gas Co.; 1st Vice-President, P. E. Demill, of Michigan; 2d Vice-President, W. H. Price, of Ohio; 3d Vice-President, Thos. R. Brown, Pa., Eng. Philada. Gas Works; Secretary, Prof. Henry Wurtz, of New York; Treasurer, J. W. Smith, of New York.

A Mysterious Explosion.—Some weeks ago an explosion, attended with serious consequences, occurred at Rising Sun, a suburb of Philadelphia. The circumstances of the case are of so unusual a nature as to be deemed worthy of insertion in the JOURNAL. A well, some twenty-five feet in depth, situated on the premises in question, was to be enclosed to be made the receptacle of a food-preserver. To insure perfect safety for the carpenter who was employed for the work, a rope with a blanket attached, was lowered into the well and vigorously shaken up and down. Upon this, a lighted lantern was lowered, when an explosion followed, inflicting serious personal injury to those about the well; while from the strong sheet of flame ejected, the rafters and roof of the shed enclosing the well were scorched and blackened for a considerable space around.

The cause of this unlooked-for accident remained for a time unexplained, though various theories for its occurrence were advanced. An invitation extended to the editor of the Journal to visit the scene of the occurrence, was accepted and made.

It was found upon examination, that the premises were lighted by a gasolene air-blowing machine. The tank for holding the gasolene was placed in a pit especially dug for the purpose, some eight feet in depth, and located some fifteen yards from the well in which the explosion had occurred. On general grounds, the probabilities pointed to this as the source of the mischief; a suspicion which was subsequently fully verified. A descent into the pit and an examination of the tank, disclosed the fact that it was and probably had been for some time slowly leaking. It was almost certain, therefore, that the oil had found its way through the cement floor of the pit, which was imperfect in some places, and had slowly filtered with the natural lead of the water through the porous earth into the well. Here, by being undisturbed, its vapor had slowly diffused into the air of the well,

forming an explosive mixture, which, on the introduction of the lighted lantern, especially after the intimate mixture of oil vapor and air had been facilitated by the agitation with the blanket, mentioned at the outset, had caused the violent and unlooked for explosion.

Fortunately, an unlooked for circumstance afforded an opportunity for demonstrating the accuracy of this inference.

To drain off the water which in wet seasons would accumulate in the gasolene pit, connection had been established by means of a pipe between the bottom of the pit and another well situated in a direction opposite to that in which the explosion had happened. This had been abandoned for some time, and was boarded over and covered with a layer of earth. On request, the well was opened, and upon the introduction of a lighted paper, there followed a roaring explosion.

The incident here narrated, though in itself quite unimportant, yet receives interest, as another indication of the very insidious and unlooked for dangers with which one may be surrounded, in employing gasolene or similar inflammable substances in quantity in the household. Curiously enough, too, not the slightest suspicion as to the true cause of the accident was entertained by the parties interested.

American Gas Wells.—It may be of interest to note the fact that extensive utilization is made in various regions of our country, of the inflammable gases which issue from the earth, in certain localities, in almost incredible volume. From a recent article by Prof. J. S. Newberry, we learn that the gas which issues from the salt wells of the Kanawha Valley has been for years employed as a fuel in the evaporation of the brine.

The town of Fredonia, N. Y., has for more than forty years been fully or partially lighted by gas which issues from springs at that place. In numerous borings made for oil in the West, gas has been met with in abundance, and was regarded formerly as a useless and inconvenient product. Within the past few years however, the gas has been largely utilized, and borings have even been made with the express design of obtaining it. In some cases these gas wells have been highly productive, furnishing an abundance of material for heating and lighting in a most convenient and manageable form. As noteworthy occurrences in this connection, the article in question states that on the Upper Cumberland, in Kentucky, gas accumulates in such quantities beneath the strata of lower silurian limestone, that many hundred tons of rock and earth are sometimes blown out with

great violence. These explosions have received the local name of "gas volcanoes." In Ohio, gas escapes from nearly all the wells bored for oil in the oil-producing districts. One well, in Knox Co., of that State, has for five years continued to send forth a constant stream of gas, of such enormous volume that when ignited it forms a jet of flame three feet in diameter and fifteen feet long. Another neighboring well constantly ejects, at intervals of one minute, the water which fills it, and thus forms an intermittent fountain 120 feet in height. Another well, in West Bloomfield, N. Y., delivering, according to Prof. Wurtz, about 15 cubic feet per second, will probably shortly be utilized to supply, for industrial purposes, the city of Rochester, some twenty miles distant.

At Erie, Pa., there are now twenty-five wells in successful operation, most of which have been bored for the express purpose of obtaining gas.

For illuminating purposes this natural product seems to be much inferior to that furnished in cities and towns, ranging about 7 or 8 candles; its chief application has thus far been for heating purposes, for which it seems eminently qualified. Upon removing by simple means some of the ingredients which diminish its illuminating qualities (carbonic acid, &c.), its value a sa lighting agent is greatly increased.

The Commercial Production of Oxygen.—The following details of the process followed by the Oxyhydrogen Gas Company, of Buffalo, N. Y., in the production of oxygen on a commercial scale, may be of interest, though it is in general the same as that previously described in the "Journal," in reference to the process of M. Tessie du Mothay.

The material employed is called manganate of soda. Whether this definition of its constitution is accurate, from a chemical point of view, we are unable to assert. The treatment of the material is thus described: "The pulverized manganate of soda is introduced into iron retorts seven feet long, one foot wide and two deep (a cross section being an ellipse). It is here heated in a current of superheated steam. The steam passes through the mass and carries with it part of the oxygen. In ten minutes the current of steam is shut off and atmospheric air is blown in; the soda salt now re-absorbs or re-unites with the oxygen, and the nitrogen escapes. . . . Air is passed in for ten minutes, and then steam as before.

"From the retorts the gas passes to the condensers, which are like the usual upright cast-iron pipes used in all gas works. Here the steam is condensed, and it washes the gas; from these the gas passes to the scrubber, where all further impurities are washed out; it then passes to the holder."*

It seems that the process followed is not identical with the published description of the patent. Several modifications in details have been found necessary in practice. The manganate also appears not to work to perfection, since it has been found to lose its porosity and agglomerate after being for some time in use. It is found necessary, therefore, to re-charge the retorts after a time with fresh material. Experience indicates that, could the steam be supplied perfectly dry, this difficulty might be obviated.

What may be the ultimate success of the company must be left for time to decide. It is at present supplying consumers with hydrogen gas at the rate of $2·50 per M., and oxygen gas at the rate of $5·00 per M.

Artificial Alizarine.—The manufacture of the artificial alizarine—the coloring matter of the madder root—seems to be steadily progressing toward a practically commercial success. It is only about three years ago that the discovery of the method of its artificial production in the laboratory was hailed by the chemical world with a spirit of rejoicing as a fresh triumph for purely scientific research; while to-day it is offered in the market at prices below that demanded for the natural product, obtained from the madder. It is said that the cheapness of the artificial material is already creating distress amongst the growers of the root in those districts of continental Europe where its cultivation forms almost the sole dependence of its population, and the near future will, in all probability, by the steady growth of the production of the artificial material, add to the severity of the competition. Whether or not the result will finally be the extinction of the madder-growing industry, remains to be seen, though the probabilities point strongly in that direction. A Philadelphia industrial establishment has lately purchased a considerable quantity of the artificial alizarine, at a cost of twenty-five per cent. below that at which the natural product can be manufactured. The steady growth of the manufacture of the artificial product deserves wide-spread recognition, as one of the most important advances of which the technical chemistry of our times can boast.

* American Artisan.

Preservation of Wines.*—Prof. Neubauer has obtained such satisfactory results with Pasteur's process of heating wine up to 60° or 65° C., that the wine growers of Ahrweiler have put it into practice. Dr. Buhl has heated his wines for some years with the best results. It is claimed that this operation kills or destroys the yeast globules and whatever germs may be present, and does not at all injure the wine.

New Process for Purification of Iron and Steel.—A recent process of this tenor, patented by Mr. Thomas Shaw, a member of the Institute, consists in directing a jet of dry steam upon the molten iron as it runs from the cupola furnace. The floor upon which the iron falls is divided into four compartments. The iron falling farthest from the nozzle, will, it is declared, be soft wrought iron; that in the next compartment, cast steel; in the next, fine cast iron; and in the nearest one, ordinary cast iron.

Diamonds from the Gold Sands of California.—Prof. Benj. Silliman has lately communicated to the American Institute of Mining Engineers the information that he has detected, in appreciable quantity, the presence of microscopic diamonds in the sands of hydraulic washings in California, associated with zircons (hyacinth), topaz, quartz, chromic iron, etc. The occurrence of diamonds of some size in the sands from the gold washings of that State is stated to be not uncommon.

New Submarine Lamp.—An instrument of this kind has been designed by M. Pasteur, which is based upon the fact that the expired and vitiated air discharged by divers, still contains enough oxygen to support the flame of a petroleum lamp.†

Accordingly, he connects with the flexible escape pipe of a diver's helmet a suitable arrangement of lamp of this kind. The lamp may be carried in the hand of the diver or may be attached to any part of the person.

The flow of the escaping air from the helmet through the lamp gives a bright flame, enabling the diver to see in all directions; rendering the employment of the expensive and troublesome electric light no longer necessary.

A New Photometer.—M. Yvon has recently communicated to

* Ind. Blätter.

† Iron age.

the French Academy the plan of a photometer based on the perception of relief, which, though we have had no opportunity of testing its practicability, seems worthy of notice from its simplicity and novelty. The arrangement is described as follows:

Let there be two plain white surfaces placed at right angles to each other: e. g., fold a sheet of paper or a card in the middle, and place it upright on a table, so that the two halves form a right angle.

Let the observer now place himself a short distance off, so that his eye is in the prolongation of a line bisecting the angle formed by the halves of the sheet, and look at the edge through a tube which has been blackened in the inside. So long as the two surfaces are unequally illuminated he has a perception of relief; when, however, the two surfaces are equally illuminated he sees what appears to be a plane surface.

From this general description of the method of observation the reader will be able, without further direction, to arrange the position of the lights to be compared and other details of the measurement.

The St. Gothard Tunnel.—From foreign sources it is stated that the elaborate machinery for piercing the St. Gothard Tunnel is almost ready for service, when this important work will be advanced with rapidity.

The progress in the tunnel at the north side, at Goshen, up to Dec. 31st, was at the rate of only 0·30 metres per day, the heading here being driven into the hardest granite. At that date, the total length driven at this end was twenty metres, the number of men employed being 100.

At Airolo the rock met with is somewhat softer, and 102 metres had been tunnelled at the close of the year. At this end, also, the masonry is begun, and from 170 to 200 persons are employed.

It is designed to preserve specimens of every rock species and variety met with in the construction of the tunnel, of which 10 or 12 collections will be made, several sets of which will doubtless find their appropriate disposition in the cabinets of the Swiss and Italian technical schools, where their value will be best appreciated.

The U. S. Naval Observatory.—The splendid telescope designed for the National Observatory at Washington will, in all probability, soon be erected and in use. The work upon the new tower and dome intended for its reception is being rapidly brought to completion.

The object-glass—the largest in the world, 26½ in. diameter and 32 feet focal length—is now finished and ready for the instrument.

The cost of the new instrument, with the necessary machinery, will be about $30,000, and that of the tower and dome erected to receive it about $15,000.

The instrument at present in use at the Observatory has an object-glass of but 9 inches diameter, so that the Professors of the Institution may be congratulated upon the splendid acquisition to its efficiency, in prospect.

If to this we add the list of new apparatus already acquired or in process of construction for the Observatory, for the observation of the coming transit of Venus, the Institution will shortly be as well or perhaps better equipped than any other of its kind in the world.

Economic Limits of Steam Expansion.—An interesting discussion upon the limit to the expansion of steam took place recently before the Manchester Scientific and Mechanical Society. The paper originating the discussion was read by Mr. McNaught, who in the course of his subject declared that he had long since reached the conclusion that the expansion of steam can be carried too far. When steam had been expanded to six times its volume, its maximum economic effect had been attained. The writer contended that no economy was to be attained beyond this point, simply because the back pressure then not only lost its value, but operated against any economical result. If more expansion was desired the piston would have to be enlarged, and that would increase the prejudicial operation of the back pressure.

In the discussion which followed, many gentlemen present took sides against the views above expressed.

Russian Sheet Iron.—The Am. Manufacturer states the fact that Messrs. Rogers and Burchfield, of Pittsburg, a few days ago, made their first consignment of Russian sheet iron to Liverpool, England: It appears from the statement of the makers, that it can be manufactured here and exported cheaper than it can be imported from Russia to England. Their present capacity for producing this important specialty is given at two tons per day, which may be largely increased.

Engineering College in Japan.—The Japanese government has recently given another significant indication of the rapid strides

which are being made in that remarkable country, in what relates to the acquisition of modern scientific knowledge, by the foundation at Jeddo of a College of Engineering, in which natives of the country are to be instructed in technology and practical engineering. Prof. Henry Dyer, formerly of Glasgow, Scotland, has been appointed the director of the new institution.

Olefiant Gas and Ozone.—An interesting observation by M. Houzeau, is the fact that a mixture of olefiant gas (heavy carburetted hydrogen) with ozone, detonates violently without the aid of either heat, light or electricity, it being simply necessary that the ozone should be present in sufficiently concentrated form.

The experiment may be repeated in public without danger, by passing very slowly a current of olefiant gas (obtained by the reaction of sulphuric acid and alcohol) through a rather wide tube, and at the same time permitting a slow current of ozone, direct from the ozonizer, to traverse a narrow tube, penetrating about one centimeter within that filled with the ethylene.

Under these circumstances, each portion of the ozone, as it mixes with the heavy carburetted hydrogen, produces a sharp detonation.

In general, the vivid combustion of the ethylene is preceded by white vapors, produced by the slow oxidation of the gas.

Testing Strength of Materials.—It is the intention of Prof. Thurston to continue the valuable experiments upon the strength of materials, with the apparatus lately described in the Journal, for automatically registering its determinations.

The work to be undertaken will be upon the metals and their alloys. Prof. Thurston therefore desires to obtain for this purpose samples of standard brands of irons, and of useful and interesting alloys, for test.

The results will all be made public. During the absence of Prof. Thurston, who sails shortly for Vienna as a member of the United States Scientific Commission, Mr. Bachman will receive and take charge of samples, which may be sent to the Steven's Institute.

Franklin Institute.

Proceedings of the Stated Meeting, February 19, 1873.

The meeting was called to order at the usual hour, with the President, Mr. Coleman Sellers, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at their stated meeting held February 12th, 1873, the following donations to the Library had been announced:

Report on the North Sea Canal of Holland, and on the Improvements of Navigation from Rotterdam to the Sea. By Major General Barnard. From Simon Stevens, Esq.

Public Works of the United States of America in 1870. From the Minister of Public Works. Paris, France.

Comptes Rendus, Sept. 9th to Nov. 18th, 1872. From the Academy of Sciences, Paris, France.

Annual Report of the Chief Signal Officer to the Secretary of War, for the year 1872. From the Chief Signal Officer.

Journal of the Society of Arts, of London, for November, 1872. From the Society.

Journal Royal Geographical Society, Vol. 41st, with a classified Catalogue of their Library. From the Society.

Quarterly Weather Reports of the Meteorological Office. From the Meteorological Committee, London.

Annals Des Pontes et Chaussees, for September and October, 1872. From the Administration of Bridges and Roads, Paris, and the Ninth Census.

The Statistics of the Population of the United States for 1870. From the U. S. Census Bureau.

The Committee on the Horse Power of Steam Boilers reported progress and was continued.

The Committee on Conflagrations made a lengthy report, through its chairman, Mr. J. B. Burleigh, who in conclusion of his remarks, called attention to a communication on the subject, at the request of the committee, by the Secretary. The communication was thereupon read. The reports referred to will be found published in the Journal of the Institute for April, 1873.

The President next announced a paper by Mr. G. P. Hachenberg,

on the subject of Musical Telegraphy, in which he explained at length a system of electrical music, and suggested a plan for a large Music Hall for the proper exhibition of the system, in connection with the coming Centennial Exhibition in 1876.

Mr. Wm. B. Le Van next presented a paper on the late Boiler Explosion at Conshohocken, which detailed the history of the exploded boiler, and the cause and effects of its explosion. The paper elicited some discussion, and is published in the Journal of the Institute for March, 1873.

Mr. Murphy next offered a paper on the Ice Gorge in the Schuylkill.

The Secretary then offered a short report on Novelties in Science and the Mechanic Arts.

Under the head of New Business, Mr. Orr offered the following:

Resolved, That the "Franklin Institute" cordially approves of a thorough Geological Survey of the State of Pennsylvania, as recommended by Prof. Lesley, in his letter to Governor Hartranft, and respectfully ask of our Legislature the proper legislation to give prompt and full effect to the same.

The resolution was adopted.

The same gentleman offered the report of the Optical Section of the Institute for the year just passed, which was accepted.

Mr. Le Van moved that a committee be appointed to fix on a formula for the Factor of Safety for the carrying of Steam Pressure, to be known as the "Franklin Institute" formula. The mover asked that, in the event of the passage of the motion, Mr. Robert Briggs be appointed as the chairman of the proposed committee. The motion was carried. The President stated that he would announce the committee at the March meeting of the Institute.

The meeting was thereupon adjourned.

WILLIAM H. WAHL, *Secretary*.

Civil and Mechanical Engineering.

EXTRACT FROM REPORT OF CHIEF ENGINEER JOHN P. CULVER, OF THE BUREAU OF ENGINEERING AND SURVEYING OF JERSEY CITY.

At the time the Board of Public Works assumed control of the water works, the foundations for building contracted for by the Water Commissioners were nearly completed, but at my request the prosecution of the work was suspended, that the advisability of substituting duplex engines for the intended Cornish engines might be considered.

On the 5th of June, 1871, the following report was made by our Consulting Mechanical Engineer and myself:

Report on Duplex Engine.—"We submit herewith our report relative to the advisability of substituting the Worthington Duplex engine for Cornish engines, for the high service supply of this city.

"Although satisfied, from knowledge previously obtained, and the comparison of statistics concerning the subject, that for the use intended in this case there was but little question concerning which engine would be preferable, we yet deemed it best to make a personal investigation, and from an actual inspection corroborate such data as have from time to time been furnished concerning the working of the Duplex engine.

"We visited the Mystic water works at Charlestown, Massachusetts, and the Fairmount water works at Philadelphia, and at both places were treated with the utmost courtesy and everything done to facilitate our obtaining desired knowledge. While availing ourselves of the information tendered by those having supervision of the works, we have also examined the mechanism of the engines, and consulted the operative engineers in charge.

"At Charlestown, Edward Lawrence, Esq., President of the works, informed me that the Duplex was adopted after a full and careful examination of the claims of the Cornish and other forms of pumping engines, and after using the Duplex for six years he is so well satisfied concerning its superiority that he has recently ordered a third engine of the same pattern but of larger dimensions, for the Mystic works.

"The two engines now in use have a capacity of five million gallons each per diem.

"The new engine is to have a capacity of eight million gallons per diem.

"As an evidence of the care with which the engines had been constructed, Mr. Lawrence informed us that the cost of repairs for the six years had been less than one hundred dollars; we were shown one of the pump valves which had been in use four years and was still in good condition.

"The duty done in raising water to an elevation of one hundred feet for each one hundred pounds of fuel consumed, was considered by Mr. Lawrence as being fully equal to the best work performed by the Cornish engines under the most favorable circumstances.

"Mr. Graff, the Chief Engineer of the Fairmount water works as well as the entire water works of Philadelphia, a gentleman whose reputation is national, and whose opinion is entitled to the most respectful consideration, informed us that the performance of his best Cornish engine had been equalled by his Duplex engines at Belmont, and the fact that he had ordered three additional Duplex engines is strong evidence of his unqualified preference.

"He says that the Duplex has given him no trouble, the costs for repairs have been so trifling as scarcely to deserve mention, and that their immunity from accidents, due to their mechanical construction, is such that he is relieved from the anxiety and care inseparably connected with the working of Cornish engines.

"The Cornish engine has the sanction of time, and the respectability that naturally clings to established usage, but in this progressive age, rife with the spirit of improvement, its past usefulness cannot guarantee its continuance, nor be used as an argument against the adoption of other engines, if the crucial test of actual duty proves their superiority.

"The Cornish engine, one of the first forms of steam engines, is only properly adapted to the peculiar service in which it originated—the lifting of water from deep mines.

"As the engine was placed on the surface and the pumps deep in the bowels of the earth, long and heavy rods were essential for their connection.

"Power was naturally employed in lifting the weights, and their gravity in falling raised the water to the desired elevation.

"In such service any intermitted action was of but little consequence, and economy in fuel a desideratum.

"The establishment of a system of annual reports excited emula

lation which resulted in the designs of the engines being improved, and they gradually assumed the perfection at last attained.

"Their high duty finally became celebrated, and in after years, as the demands for pumping engines for water works developed, it was natural that the Cornish engine should be selected, the more particularly as the service was in many respects similar; the water being obtained from pits or shafts sunk through the chalk formations, until the apparently inexhaustible reservoir that underlies so much of England was reached.

"Once used as pumping engines for the water works of towns, modifications adapted them to the conditions in which we are now using them, and so far as economical use of fuel is concerned, they still, under favorable conditions, maintain their reputation, and although equalled, have never been excelled.

"Experience tends to show, however, that in many other respects as essential as economy they are inferior.

"The efficiency of a pumping service of a city underlies the prosperity, comfort, safety, and health of its inhabitants, and such efficiency is dependent to a great extent on the durability of the engines and their freedom from accidents, and on these points the Cornish engines are defective.

"They are in fact the most precarious form of engine known, requiring not only the utmost skill upon the part of the attendants, but are liable to accidents against which it appears impossible to guard, and the immunity we enjoy is no evidence that the works may not be disabled at any time; in proof of which it may be said that there is scarcely a Cornish engine in the country but what has been subject to dislocation and fractures, more or less extensive; which, being due to their form and action, scarcely admits of a remedy.

"The intermittent action of the Cornish engine is a serious argument against its adoption, entailing as it does the necessity for a stand-pipe, a contrivance whose objectionable features do not appear to require much comment, as we have so lately realized the danger incident to such a device, and are about to experience the cost of its maintenance in the construction of the tower at Belleville.

"An immense and weighty column of water in the stand-pipe alternates from a state of comparative rest to one of motion at every stroke of the pump, accompanied with very great and irregular strains upon the pump and contiguous valve chambers and pipes, which when augmented by a slight irregularity in the movements of

the valves (liable to occur from accidental causes), become so percussive as to cause serious and disastrous breaks.

"Various attempts have been made to construct new forms of engines in place of the Cornish; notably, the Hartford Cam engine, the Shield engine at Cincinnati, and the so-called Double-Action Cornish engine at Brooklyn, but none of them met with such success as to warrant their introduction, and we believe they have not been duplicated.

"A failure of considerable magnitude was also experienced at Detroit.

"The Worthington Duplex appears to be the engine destined to supplant the Cornish, and from the date of its introduction its reputation has grown and increased, until now its superiority is generally acknowledged by those most competent to decide.

"Seventeen years ago three Worthington engines were put up at Savannah; others of the same kind were erected at Cambridge in the year 1856, which, under careful trial, excelled every other engine in the country, our own at Belleville included.

"The Charlestown engines (being the first of the Duplex form) were erected in the year 1856, and their performance is asserted to be the best on record.

"At Cambridge they have recently put in a second engine of five million gallons capacity, also one at Salem of same size.

"One has been running at Harrisburg, Pa., almost constantly for ten years with almost no repairs.

"The Duplex is also to be used at Providence, Poughkeepsie, and other points.

"Two are running at the Newark water works, and several others could be enumerated if necessary, but we deem the foregoing sufficient to convince your honorable body that in using the Worthington Duplex engine you would neither be elucidating a vague theory nor testing an untried experiment.

"A noticeable feature and valuable characteristic of the Duplex engine is the noiseless way in which it performs its work; there is no concussion nor even an appreciable jar in the engine or its attachments; the piston acting directly on the water without the intervention of vast moving masses of metal, reduces, if it does not obviate, the danger of fracture or dislocation to which the Cornish engine is liable.

"The water-flow throughout the delivery main is so equable as to

scarcely disturb a sensitive gauge placed thereon, and the discharge into a reservoir is so uniform as to be without perceptible pulsation.

"The location of two Duplex engines on Bergen Hill will serve equally to render the supply for the upper service plenteous, and to fill the storage reservoir when it shall be constructed.

"Considering the foregoing, and that the present foundation of the new engine house can be utilized, while there will be no necessity for the erection of a stand-pipe and inclosing tower; and that the beam walls and second story of engine house will not be required, it is manifest that the simplest, safest, most durable and inexpensive engine should be selected.

"So that from motives of economy, believing that a great saving can be effected and the work done as well if not better than in any other manner, we would give our most emphatic preference to the Worthington Duplex engines, and recommend that they be used in the new works on Bergen Hill."

The recommendations contained in this report having been adopted, suitable changes were made in the plan of the building (which is now being completed), and contract entered into with Henry R. Worthington, Esq., for two of his Duplex engines, with boilers and attachments complete. One of these engines, as before mentioned, has been transferred to the pumping works on the Passaic river, the other is now being set up in the building on Bergen Hill.

The New Tin Fields.—The most favorable accounts continue to be received from the recently discovered tin fields in Queensland.

The discoveries have attracted large numbers to the region, and preparations for mining are being vigorously pushed. In one locality alone, over 1400 acres of claims have been taken up by different parties, who are making preparations for conducting sluicing operations upon a large scale, the water supply being abundant and every natural facility present.

As an indication of the ultimate value of these claims, it is stated that the ore yields 72 per cent. of metallic tin, and that all the prospects thus far obtained have averaged a quarter of a pound of ore to the dish.

It is proposed, by parties largely interested in the mines, to introduce Chinese labor for working them.

GAUGING OF RIVERS.

By Bvt. Brig. Gen. Henry L. Abbot, Major of Engineers.

(Continued from page 314.)

Tests and Extension of the Formulæ from the New Data.—This is not the place to explain in detail the principles upon which these formulæ are based; nor how to apply them to complex problems, such, for instance, as the rise in water surface which results from a given increase in discharge. These matters are fully discussed in the Physics and Hydraulics of the Mississippi. In this paper, I propose only to consider their practical applicability to water flowing in natural channels, as illustrated by actual measurements.

The observations available in deducing their constants—including not only all our own but also all published experiments of value—were thirty in number, and they are given in the following table, numbered from 50 to 79 inclusive. They are discussed with great care on pages 301—10 Physics and Hydraulics of the Mississippi.

The work of MM. Darcy and Bazin appeared four years after the publication of the Mississippi Report, but in a joint review of the two works M. Victor Fournié, Engineer of the Corps des Ponts et Chaussées, states that the authors were ignorant of the existence of the latter prior to the publication of their own. The new laws and formulæ announced have, therefore, received no discussion from M. Bazin; and his report must be studied, in order to determine what means it supplies for testing our conclusions. It is a work of high scientific merit and practical importance, treating of many branches of hydraulics which have no immediate connection with the gauging of rivers.

MM. Darcy and Bazin have removed one important error, which for three quarters of a century has encumbered science, viz., the law known as Coulomb's. This law avers that the friction of water upon the walls of its bed is independent of the material of which that bed is made. Dupuit—whose treatise on the Theory of Flowing Water, published in 1848, is a monument of scientific ability—doubts the truth of this law. Certain results, reported on page 318 of the Physics and Hydraulics of the Mississippi, suggested the same conclusion. M. Bazin has finally demonstrated this law to be false. He divides his experiments into four classes: those where his little canals were lined with very smooth materials, as polished cement, planed wood etc.; those lined with slightly rough materials, as cut stone, brick s planks, etc.; those quite rough, as rubble masonry; and, lastly, those

lined with earth. He proposes a formula, with different constants for each class; and shows conclusively that these differences are necessary to make experiment accord with theory.

He seems, however, to have overlooked one logical sequence of this new principle, viz., that the velocity at the perimeter, and not the mean velocity, must of necessity enter his equations. This necessity, which was theoretically established by M. Dupuit, in 1848; which was recognized in our formulæ; and which becomes doubly unavoidable since Coulomb's law is shown to be false—is rejected by M. Bazin. In fact, he simplifies instead of complicating the usual form of the equation for water flowing uniformly; no doubt because his investigations did not lead him to discover the law which governs the action of cohesion among the different particles of water, in transmitting the effect of the primitive resistance. Apart from the classification of channels, his formulæ are, therefore, theoretically no more exact than those of de Prony and other writers, and are only superior in practice because of his better data for determining the constants.

To his first three classes of channels our formulæ have no application, as was fully and repeatedly stated in the Physics and Hydraulics of the Mississippi. To some of his experiments in earthen channels they should apply, provided their constants were deduced with sufficient accuracy to include streams so very much smaller than any available in our investigations. I have, therefore, carefully examined these new data, applying to them the discrimination used in selecting observations from which to deduce our constants.

The Darcy and Bazin data for earthen beds comprise:

1. Observations upon the feeders Grosbois and Chazilly of the canal of Bourgogne. Series 37, 38, 41 and 49 were upon portions of these feeders where the bottom was of earth, but pebbly, except in the last, which was muddy. The only remaining series, 47, 48 and 50, were made (see pp. 454 and 455) where a few plants grew in the bed.

2. An experiment on the canal Marseille, which closely resembled a natural channel, and which was therefore an unexceptionable observation.

3. Dubuat's experiments on the Canal du Jard,—not applicable to a river formula, as is fully shown on page 306 Physics and Hydraulics of the Mississippi.

4. Dubuat's observations on the river Haine; two of which were

used in our investigations, and the other two shown to be inapplicable, on page 307.

5. The observations of Funk on the Weser, concerning which M. Bazin remarks: "It is to be noted that Funk has almost always adopted the same slope for an entire group of experiments, a circumstance which does not occur in a natural channel. The original data appear, according to Hagen, to have been corrected and co-ordinated so as to render uniform, slopes at first different." It is clear that such observations possess no value.

6. The experiments of Bruning on the branches of the Rhine. M. Bazin states, on the authority of Hagen, that these slopes were not measured; and that they either "were computed subsequently, so as to place the results in accord with existing formulæ, or were determined by a later leveling in 1797. Such data evidently are valueless.

7. Some old experiments of Bonati on the Po, and of the Roman school of Ponts et Chaussées on the Po and the Tiber. M. Bazin remarks "the value to be assigned to the slopes for these observations is not better determined." He does not report them in detail, and as M. de Prony's Recueil de Cinq Tables, from which he obtained them, is not at hand, I have been unable to make use of them.

8. A series of unpublished experiments on the Seine, executed at Paris in 1851 and 1852 under direction of M. Poiree, Ingenieur des Ponts et Chaussées. They were made with floats, and are the mean of many gaugings made at about the same stands of the river. M. Bazin calls them "good," as, no doubt, they are.

9. A series of experiments made on the Seine at Poissy, Triel and Meulan, in 1852 and 1853 under the direction of M. Emmery, Ingenieur des Ponts et Chaussées. Respecting these experiments, it is to be remarked that the water level varied during the observations. The mean amount was about 8 inches, the maximum being nearly 2 feet. With a river having a mean depth of only about 12 or 13 feet, it would seem that such oscillations—probably tidal—must have destroyed all precision in the measurement of slopes. Still, I have applied the formula to the data, although regarding them as of very doubtful accuracy.

10. A series of experiments on the Saone, in 1857–59, conducted, until his death, under the direction of M. Leveille, Ingenieur en chef des Ponts et Chaussées. This series of ten observations is stamped with the evident inaccuracy of an unvarying slope, while the river

increases its discharge twenty-two hundred per cent., and its mean radius, five hundred per cent. (from 3 to about 16 feet). It is certain that they can possess no value for testing river formulæ, and I have therefore rejected them.

In fine, then, I find that the work of MM. Darcy and Bazin furnishes 49 measurements admissible for testing river formulæ; although the nine upon the lower Seine are of doubtful merit. The others are unquestionably of high value.

The contributions of M. Grebenau consist of six measurements on small natural streams, made with great care by himself, and fully reported; of five gaugings of Bavarian rivers made in 1856–57; of three recent gaugings of the Rhine by Baden engineers; and of a measurement on a small canal by M. Strauss. His thorough manner of discussing his data leaves nothing to be added.

To these 64 observations I have applied our formula; and, to complete the discussion, have added our own data and applied to them the new formulæ of MM. Darcy and Bazin, and M. Hagen. The following table exhibits the results in detail, numbered as in the original reports. The first 49 observations are those from the work of MM. Darcy and Bazin. The next 30 are the data from the Physics and Hydraulics of the Mississippi. The next 15 are from the large work, or from a more recent pamphlet by M. Grebenau. The next two are from a forthcoming report, by General G. K. Warren, upon his late surveys of the Upper Mississippi; the former was made at St. Paul, and the latter at Fort Snelling. The last two are from the report of Mr. Thos. C. Clarke, Chief Engineer of the Railway Bridge at Quincy, Ills. His measurements were carefully made at that city in 1866–67; and, as nearly as practicable, at low water and high water stages, the difference in level being 12·4 feet.

In the table, the discrepancies, applied with their signs to the computed velocities, reduce them to those observed.

A cursory inspection of this table makes it evident that our formula accords in a remarkable manner with measurements upon channels varying from the dimensions of the Mississippi river to those of diminutive canal feeders, and comprising a range of slopes from 0·000 004 to 0·009, while the formulæ of MM. Darcy and Bazin and M. Hagen have a more limited application. They are improvements upon the old formulæ for large rivers, as appears from the following figures, which denote the sums of the discrepancies in mean velocity for the 30 observations reported in the Physics and Hydraulics of the Mississippi, and for which the sum of the mean

velocities is 115·5 feet. M. Hagen had access to these observations in deducing his constants.

Measurements upon Natural Channels, with Tests of Formulæ for Mean Velocity.

No.	Stream.	Original. No.	Original. Series.	Cross Section. Area.	Cross Section. Width.	Cross Section. Wetted Perimeter.	Cross Section. Mean Radius.	Slope.	Observed Mean Velocity.	Discrepancy. D. B. Formula.	Discrepancy. Hagen Formula.	Discrepancy. H. A. Formula.
				sq. ft.	ft.	ft.	ft.		ft.	ft.	ft.	ft.
1	Feeder Chazilly	1	37	9·5		9·9	0·96	0·000 792	1·234	—0·062	—0·072	—0·284
2		2		14·9		12·3	1·21	0·000 808	1·667	+0·067	+0·193	—0·062
3		3		19·4		13·8	1·41	0·000 858	1·815	—0·091	+0·208	—0·097
4		4		22·9		14·7	1·56	0·000 842	1.998	—0·060	+0·314	—0·013
5		1	38	9·3		9·7	0·96	0·000 957	1·244	—0·187	—0·106	—0·351
6		2		14·1		11·9	1·18	0·000 929	1·703	0·000	+0·213	—0·071
7		3		18·8		13·3	1·41	0·000 993	1.798	—0·252	+0·152	—0·184
8		4		22·2		14·4	1·54	0·000 986	1·959	—0·255	+0·244	—0·123
9		1	41	11 3		10·8	1·04	0·000 445	0·962	—0·087	—0·275	—0·400
10		2		18·1		13·1	1·38	0·000 450	1·296	—0·091	—0·132	—0·294
11		3		23·9		14·6	1·57	0·000 455	1·401	—0·112	—0·125	—0·312
12		4		27·2		15·9	1·71	0·000 441	1·510	—0·106	—0 074	—0·277
13	Feeder Grosbois	1	47	11·8		10·8	1·09	0·000 464	0·820	—0·295	—0·455	—0·589
14		2		17·2		12·5	1·38	0 000 450	1·326	—0·027	—0·102	—0·266
15		3		23·0		14·1	1·63	0·000 479	1·434	—0·172	—0·134	—0·337
16		4		26 8		15·7	1·71	0 000 493	1·683	—0·017	+0·070	—0·153
17		1	48	10·1		10·2	0·98	0·000 555	0·984	—0·157	—0·262	—0·415
18		2		15·4		11·8	1·30	0·000 555	1·480	+0·059	+0·045	—0·148
19		3		20·9		13·4	1·56	0·000 525	1·575	—0·047	+0·018	—0·199
20		4		25·9		14·1	1·71	0·000 515	1·746	0·000	+0·122	+0·037
21		1	49	10·9		11·4	0·96	0·000 250	0·886	+0·155	—0·194	—0·227

22	....	2		17·1		12·9	1·32	0·000 276	1·336	+0·321	+0·050	—0·026
23	....	3		24·2		15·5	1·57	0·000 246	1·362	+0·245	—0·015	—0·092
24	....	4		30·8		17·3	1·78	0·000 275	1·467	+0·148	—0 027	—0·136
25	....	1	50	11·8		11·3	1·05	0·000 310	0·817	—0·065	—0·353	—0·422
26	....	2		18·0		12·7	1·42	0·000 290	1·260	+0·151	—0·086	—0·175
27	....	3		25·4		15·4	1·69	0·000 330	1·296	—0·052	—0·204	—0·319
28	....	4		32·0		17 3	1·85	0·000 330	1·411	—0·085	—0·157	—0·310
29	**Canal Marseille**..........................	7	1	66		23	2 9	0·000 430	2·536	+0·130	+0·483	+0·102
30	**Seine at Paris**............................	1		1 978		349	5·7	0·000 127	2·094	—0·126	—0·256	—0·371
31	....	2		2 570		363	7·1	0·000 133	2·264	—0·385	—0·379	—0·406
32	....	3		3 176		377	8·4	0·000 135	2·418	—0·580	—0·464	—0·680
33	....	4		3 692		390	9·5	0 000 140	3·370	+0·076	+0·287	+0·039
34	....	5		4 421		405	10·9	0·000 140	3·741	+0·132	+0 438	+0·150
35	....	6		5 108		419	12·2	0·000 140	3·816	—0·053	+0·322	+0 009
36	....	7		6 372		439	14·5	0·000 140	4·232	—0·085	+0·423	+0·058
37	....	8		6 929		461	15·0	0·000 140	4·512	+0·110	+0·638	+0·256
38	....	9		8 034		504	15·9	0·000 172	4·682	—0·375	+0·554	+0·055
39	....	10		8 668		516	16·8	0·000 131	4·800	+0·240	+0·745	+0·360
40	....	11		9 522		518	18·4	0·000 103	4·689	+0·427	+0·612	+0·321
41	**Seine (Meulan)**............................	1		5 982		842	7·1	0·000 090	2·310	+0·140	—0·166	—0·234
42	....	2		6 488		845	7·7	0·000 087	2·313	+0·046	—0·251	—0·314
43	**Seine (Triel)**.............................	3		5 640		502	11·2	0·000 057	2·363	+0·024	—0 519	—0·527
44	....	4		6 375		513	12·4	0·000 060	2·359	—0·212	—0·700	—0·728
45	**Seine (Poissy)**............................	5		7 475		551	13·6	0·000 050	2·372	—0·095	—0·735	—0·711
46	....	6		7 952		560	14·2	0·000 054	2·595	—0·052	—0·621	—0·634
47	....	7		8 996		567	15·9	0·000 062	2·911	—0·116	—0 571	—0·638
48	....	8		9 733		578	16·8	0·000 067	3·101	—0·155	—0·525	—0·639
49	....	9		10 400		582	17·8	0·000 075	3·330	—0·233	—0 483	—0·634
50	**Mississippi R.**............................	1		193 968	2 653	2 693	72·0	0·000 020 5	5·929	+1·882	—0·235	+0·038
51	....	2		195 349	2 656	2 696	72·4	0 000 017 1	5·887	+2·177	—0·109	+0·243
52	....	3		180 968	2 421	2 461	73·6	0·000 003 4	4·034	+2 363	—0·584	+0·259
53	....	4		183 663	2 429	2 469	74·4	0·000 003 8	3·977	+2·196	—0·753	+0·066

Measurements upon Natural Channels, with Tests of Formulæ for Mean Velocity—(Continued).

No.	Stream.	Original. No.	Original. Series.	Cross Section. Areas.	Cross Section. Width.	Cross Section. Wetted Perimeter.	Cross Section. Mean Radius.	Slope.	Observed Mean Velocity.	Discrepancy. D. B. Formula.	Discrepancy. Hagen Formula.	Discrepancy. A. H. Formula.
				sq. ft.	ft.	ft.	ft.		ft.	ft.	ft.	ft.
54	....	5		148 042	2 214	2 247	65·9	0·000 068 0	6·957	—0·087	—0·243	—0 809
55	....	6		178 137	2 729	2 779	64·1	0·000 063 8	6·949	+0·239	—0·076	—0·460
56	....	7		179 502	2 732	2 782	64·5	0·000 043 6	6·825	+1·255	+0·211	+0·071
57	....	8		78 828	2 507	2 530	31.2	0·000 022 3	3·523	+0·842	—0·591	—0·397
58	....	9		134 942	2 556	2 589	52·1	0·000 030 3	5·558	+1·418	—0·037	+0·043
59	....	10		150 354	2 580	2 621	57·4	0·000 048 1	6·319	+0·824	—0·024	—0·198
60	B. Plaquemine........................	11		5 560	292	303	18·3	0·000 206 4	5·198	—0·824	+0·633	—0·045
61	....	12		4 259	268	278	15·3	0·000 1437	3 959	—0·553	+0·029	—0·387
62	B. La Fourche........................	13		3 738	223	238	15·7	0·000 044 7	3·076	+0·523	—0·201	—0·207
63	....	14		3 025	223	232	13·0	0·000 037 3	2·843	+0·761	—0·050	+0·021
64	....	15		2 957	223	231	12·8	0·000 036 6	2·807	+0·769	—0·055	+0 030
65	....	16		2 868	223	230	15·7	0·000 043 8	2·789	+0·261	—0·476	—0·077
66	C. and O. C. feeder........................	17		121	23	32·7	3·7	0·000 698 5	3·032	—0·758	+0·517	—0 071
67	....	18		119	23	32·5	3·7	0·000 698 5	2·723	—1·037	+0 208	—0·359
68	Ohio River........................	19		7 218	1 073	1 074	6·7	0·000 693 3	2·515	+0·378	+0·095	+0·030
69	River Haine........................	20		248·5	48	50·5	4·9	0·000 165 3	2·495	+0·315	+0·218	+0·025
70	....	21		306·4	50·5	53·4	5·7	0·000 155 9	2·558	+0·200	+0·127	—0·088
71	Canal........................	22		50	18	20·6	2·4	0·000 063 1	1·134	+0·299	—0·223	—0·196
72	River Rhine........................	23		19 135	1 155	1 163	16·5	0 000 097 7	3·575	—0 308	—0·252	—0·481
73	....	24		6 304	557	563	11·2	0·000 099 9	3·277	+0·181	+0·112	—0·054
74	River Waal........................	25		14 782	1 328	1 334	11·1	0·000 104 4	3·165	+0·019	—0·008	—0·181
75	Rhine........................	26		5 341	700	704	7·6	0·000 117 4	2·917	+0·314	+0 239	+0·097
76	Yssel........................	27		1 930	321	324	5·9	0·000 116 6	2·773	+0·578	+0·416	+0·299
77	Tiber........................	28		2 355	243	249	9·4	0 000 130 6	3 413	+0·236	+0·382	+0·138
78	Neva........................	29		43 461	1 218	1 227	35·4	0·000 018 9	3·230	+0·957	—20	+0·497

79	Great Nevka	30		15 554	881	893	17·4	0·000 014 9	2·049	+ 0 482	+ 0·824	—0.519
80	River Schwarza	1		46·7	56·6	58·3	0·80	0 009 000	2·528	—1·186	+0·737	—0·106
81		2		52·3	50·8	52·9	0·99	0·005 200	2·544	—0·880	+0·726	—0·019
82	Hockenbach, I—II			10·5	11·1	12·0	0·87	0 000 778 3	1·440	+ 0·263	+0·198	—0·022
83	" II—III			10·3	11·0	11·8	0·88	0·000 796 6	1·463	+ 0·259	+0·209	+0·020
84	Speyerbach			30 2	16·1	19·7	1·54	0·000 466 6	1·814	+ 0·297	+0·300	+0·044
85	Hübengraben			3·8	4·8	6·4	0·59	0·001 300 0	1·424	+ 0·360	+0·310	—0·002
86	Salzach	1		4 005·6	375·9	377·8	7·00	0·000 360 0	4·118	—0·197	+1·020	— 0·376
87	Saalach	2		86·9	60·4	61·2	1·38	0·001 035 7	2·155	+ 0·125	+ 0·515	+0·144
88	"	3		96·7	71·3	71·8	1·34	0·001 136 4	1·970	—0·127	+0·327	—0·044
89	Isar	5		300 1	153·7	161·6	1·85	0·002 500 0	3·997	—0·108	+1·797	+0·990
90	"	6		1 063·4	172·2	176·0	6·04	0·002 500 0	7·212	—3·054	+3·237	+1·717
91	Rhine	1		4 650·1	590·5	606·3	7·67	0·001 250 0	4·921	—1·761	+0·933	—0·315
92	"	2		13 725·5	590·5	633·8	21·65	0·001 000 0	8·858	—5·745	+2·399	+0·185
93	"	3		14 149·8	1 440 0	1 458·3	9·72	0·000 112 0	2·910	—0·086	—0·095	—0 276
94	Lauter Canal	4		56·4	29·6	31·0	1·82	0·000 664 0	2·106	+0·020	+0·356	+0·023
95	Upper Mississippi			5 010·1	462·0	467·0	10·85	0·000 028 9	1·509	—0·124	—1 024	—0·351
96	" "			3 441·0	773·0	778·0	4·42	0·000 222 7	2·611	+ 0·165	+0·339	+0 128
97	" "			15 911	1 607	1 612	9·87	0·000 074 34	2·941	+ 0·477	+0·113	—0·019
98	" "			51 610	3 160	3 172	16·27	0·000 074 34	3·898	+ 0·533	+0·267	+0·075
	Sum								282·183	45·861	38·224	25·463

Ellet's discrepancy, 45·4 feet; Dubuat's, 40·4 feet; Girard's, 37·4 Young's, 33·4 feet; Chezy-Young's, 32·9 feet; St. Venant's, 30·7 feet; Prony Eytelwein's, 29·5 feet; Prony-Wiesbach's, 28·8 feet; Chezy-Eytelwein's, 28·4 feet. Prony's two formulæ, 28·1 feet; Chezy-Downing's, 26·7 feet; Dupuit's, 25·1 feet; Darcy-Bazin's, 22·9 feet; Hagen's, 8·7 feet; Humphreys-Abbot's, 6·4 feet.

I have not taken the trouble to apply the older formulæ to the new data, and cannot therefore institute a similar comparison for them.

It has seemed to me advisable to closely scrutinize the above table, with a view to learn whether the new observations afford means of improving the form or constants of our formula. In such an investigation, it appears proper to classify the data according to the area of cross section, as this quantity is usually in natural channels the governing element which decides the character of the stream. When the discharge, and hence the area of cross section, is large, the depth is usually considerable and the slope gentle. With a less volume of water, the depth decreases and the slope increases. For very small sections, like those of canal feeders, the law of variation in the coefficients which take into account the action of cohesion is severely tested; and useful suggestions as to the laws governing these curves may be obtained. Guided by these views, I have prepared the following table to analyze the results shown in the last.

Preliminary Analysis of Data contained in preceding Table.

Area of Cross Section, varying between	No. of Obs.	Sum of observed Velocities.	Sum of computed Velocities.			Sum of Discrepancies.			Percentage of Discrepancies.		
			D. B. Formula.	Hagen Formula.	H. A. Formula.	D. B. Formula.	Hagen Formula.	H. A. Formula.	D. B. Formula.	Hagen Formula.	H. A. Formula.
Sq. ft.											
200 000 and 10 000	19	89·914	80·709	92·058	93·405	22·123	8·124	5·451	24·6	9·1	6·1
10 000 and 1 000	35	116·880	120·266	112·419	121·012	14 108	18·447	11·438	12·1	15·8	9·7
1 000 and 50	11	27·250	29·171	22·199	26·743	3·899	5·497	2·061	14·3	20·2	7·5
Less than 50	33	48·139	49·814	47·529	54·450	5·731	6·156	6·513	11·9	12·8	13·5
Total,	98	282·183	279·960	274·205	295·610	45·861	38·224	25·463	16·3	13·5	9·0

An examination of this table leads to interesting results. Our formula, which gives a less percentage of error than the others for all but the smallest of the four classes of natural streams, has its largest discrepancies in channels less than 50 feet in cross section.

With this class—which MM. Darcy and Bazin's excellent experiments permit for the first time to be closely analyzed,—our formula

gives a discrepancy of about 14 per cent., or nearly double that for larger streams; and, moreover, nearly all of the computed are in excess of the observed velocities. This is exactly what was anticipated when 100 square feet was fixed upon as a limit of applicability in respect to cross section. To render the reason clear, it will be needful to glance at some of the principles upon which our formula is based.

When water is moving uniformly, the accelerating are equal to the retarding forces. The former, in a straight channel, are measured by the product of the weight of the water into the sine of the slope of its surface. The latter arise from the joint action of two forces—adhesion to the bed and cohesion of the different particles of water to each other. The first is evidently the primary resistance, the second being rather a force which regulates the distribution of the effects of adhesion to the bed among the interior particles of the fluid mass. The resistances may therefore be expressed by the product of the area of the surface which experiences resistance to motion, multiplied by a function of the velocities at that surface—the particular form of this function remaining to be determined by experiment. The mean velocity is to be deduced from this mean exterior velocity by applying the laws governing the action of cohesion. A knowledge of these laws, therefore, becomes of primary importance—indeed is essential—in the solution of the problem.

The investigations upon the Mississippi river first revealed the laws governing the action of cohesion; and subsequent tests in Europe have established the accuracy of the conclusions at which we arrived. They may be briefly set forth as follows—or rather such of them as belong to this discussion:

In any vertical plane parallel to the current, there is a resistance to motion at the bottom and at the water surface. The latter is chiefly a transmitted resistance; probably arising from upward currents, occasioned by inequalities at the bottom, which retard the upper layer not only by shocks and boils in breaking, but also by actually transferring water moving at a slow rate near the bottom, to the surface. According to M. Bazin's views, the surface retardation is partly due to inequalities of movement occasioned by the relative absence of pressure, and it appears probable that this may be one cause of the phenomenon. Although, in the Mississippi Report, it is mathematically proved that this depression cannot be due to friction against the air, that work has been repeatedly misquoted by careless

writers as advocating this theory. Whatever the causes may be, it is a fact well established by observation that there is a resistance at the surface, and that its law of transmission is the same as that governing the change of velocity at different distances from the bottom. For framing a formula, it is, therefore, evident that surface and bottom must both be regarded as loci of the primary resistances to motion.

The law of transmission in a vertical plane is represented by the arc of a parabola whose axis is parallel to the surface, and usually from one to three tenths of the depth below it. The axis of this parabola moves up and down parallel to itself, as the relative resistances at the surface and bottom vary under the influence of winds or other extraneous forces. For the same depth and mean velocity, the curve itself is unvarying. As the depth or mean velocity is changed, the reciprocal of the parameter of the parabola varies in a manner indicated by the expression $\sqrt{b\,v}$, in which $b = \frac{1{\cdot}69}{\sqrt{D + 1{\cdot}5}}$ The complete law for the change of velocity from surface to bottom in any vertical plane parallel to the current is, therefore, given in feet by the following equation, in which $V_{d'}$ denotes the maximum velocity and d' the depth below the surface at which it is located. V denotes the velocity at any depth d, the total depth being D.

$$V = V_{d'} - \sqrt{b\,v}\left(\frac{d - d'}{D}\right)^2$$

All the details of this parabolic law for the transmission of resistances through the fluid, were so clearly established for rivers by the investigations upon the Mississippi—not excepting even the effect of wind upon the mean vertical curve—that it does not seem necessary to thoroughly discuss the new data furnished by MM. Darcy and Bazin; especially in view of the following facts:

Their observations were confined to small artificial canals of various shapes, so narrow in proportion to their depth that the vertical and horizontal curves must have mutually affected each other to such a degree as to render very difficult a study of either of them separately. Moreover, owing to the shallow depths (2·16 feet being the maximum for the rectangular canals), the velocity was measured at a very limited number of points, usually only three or four, in each vertical plane. This not only prevents an exact determination of the curvature and depth of axis, but also the detection, through the law

of continuity, of errors of observation; which is the more to be regretted because such errors are very liable to occur, especially in the most characteristic parts of the curve near the bottom. In reference to some palpable discrepancies of this kind, M. Bazin remarks: "These anomalies, which only occur in the vicinity of the wetted perimeter, arise, because the smallest displacement of the instrument introduces a considerable error in estimating the velocity, when the extremity of the gauging tube is only separated about three quarters of an inch from the bed, near which the velocity always varies most rapidly." Still another cause of error in these observations has been suggested by M. Victor Fournié. The Darcy-Pitot tube, by which the velocities were measured, give the *instantaneous*, and not the *average continuous* velocity at each point. If it were possible to measure the velocity at all the points simultaneously, this might be no disadvantage; but as each point must be measured separately, and as the axis of the vertical curve is constantly oscillating under the influence of varying winds, thus occasioning the *pulsations* often reported by observers upon rivers, it is a serious cause of uncertainty in the observations. M. Fournié remarks: "It appears that the inadmissible irregularities of M. Bazin's curves of equal velocity may be thus explained. The perturbations may have masked the true laws."

An examination of the data—which were collected with great care and labor, and which are, undoubtedly, sufficiently exact for general purposes—leads to the conclusion that they afford strong confirmation of the truth of our parabolic theory, and make known the additional fact that the effect of the resistances at the sides of the channel is to depress in that vicinity the axes of the vertical parabolas—an effect which might naturally be anticipated in so narrow streams.

(To be continued.)

Steam on Common Roads.—The subject of introducing steam on city streets and common roads is a problem with us still in an unsettled state; while abroad the experiment seems to have been successfully undertaken.

Two main lines of tramway have recently been opened in Portugal, one of which leads from the capital in a northerly and north-easterly direction. The tramways are laid on the common road, the sharpest curves yet laid down having a radius of forty feet.

The traction wheels of the locomotives and the side wheels of the carriages run on longitudinal sleepers, the tires of the driving wheels projecting over the edges of the sleepers, so that slight sinking of the latter will not affect the wheels. The locomotives and cars have trucks, run on a central guide rail, the wheels being flanged on both sides.

HORSE-POWER OF BOILERS.

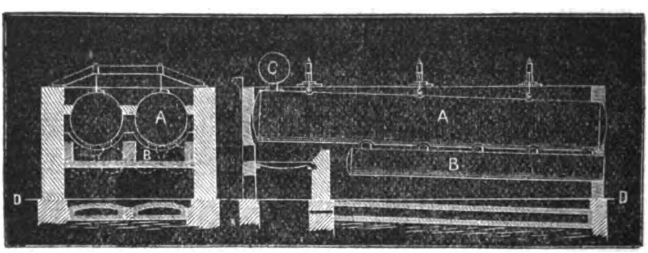
By W. Barnet LeVan, Engineer.

The term "horse-power," in its application to boilers, has heretofore been no less indefinite than the same term in its application to the steam engine. It has been customary to fix upon some unit of heating surface as the measure of the horse-power of a steam boiler. The boiler is supposed to furnish a definite amount of steam at the working pressure employed, this amount depending on the heating surface; and the utilization of all this steam, under the most favorable conditions, would thus furnish, through the medium of an engine, a certain amount of work or a certain horse-power. But experiments have shown that the same quantity of water evaporated by a boiler may produce widely different results in the engine, and the work done by the engine dependent upon the evaporation of the water may be changed very materially by the condition of the boiler, as well as by its form and construction. The boiler will do different quantities of work in the same engine, or in different engines under various conditions of working; these conditions being the pressure, the degree of expansion, and the speed of the piston. The horse-power of a boiler will therefore vary with the kind of steam engine, and with its condition.

It is, however, conceded that the amount of water evaporated into dry steam per hour under the ordinary conditions is the best measure of the capacity of the boiler. This amount has been heretofore generally stated at one cubic foot of water evaporated per hour to produce one horse-power.

I propose in this paper to show the horse-power of boilers, as shown by the experiment made at Belmont upon the boilers, engines and pumps of the Water Department, by a commission of gentlemen appointed by the Select and Common Councils of this city, of which Commission I had the honor of being a member.

BOILERS.

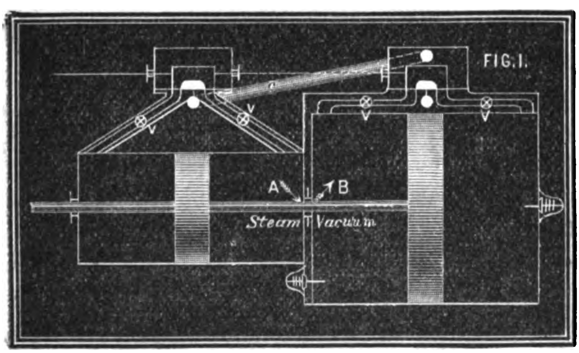


These experiments were made in May, 1872, with six Elephant or French boilers, of the following dimensions:

Total length in feet,	30·88
Diameter in inches,	54
Total length of mud drums in feet,	22
Diameter of mud drums in inches,	28
Number of mud drums,	2
Number of necks,	10
Length of necks in inches,	12
Diameter of necks in inches,	12
Length of grate bars in inches,	60
Width of grate-bars in inches,	52
Grate surface of one set in square feet,	43·33
Total grate surface of three sets in square feet,	130
Total heating surface of one set of boilers in square feet,	508
Total heating surface of one set of mud drums in sq. feet,	616
Total heating surface of the three sets in square feet,	3372
Ratio of heating surface to grate surface,	26 : 1

DESCRIPTION OF THE DUPLEX PUMPING ENGINE.

The pumping engines are Worthington's Compound Duplex Engine, which consist of two high-pressure and two low-pressure cylinders. The initial pressure of the steam is used during the full stroke of the small cylinders, and the low pressure cylinders receive upon their increased piston area the steam discharged from the high-pressure ones. The high and low-pressure cylinders are placed in line, the former being in front of the latter, and the same piston-rod passing through both, and of such a length as to be attached to the plunger of the pump cylinder situated in advance of the high-pressure cylinder, so as to allow for the guides of the cross-head, and held in this position with the water cylinders in one direct line by four wrought-iron rods, forming an open space in which are placed two



Duplex Pumping Engine Cylinders.

single-acting air-pumps for each pair of steam cylinders, which are driven by rock shafts off the main piston-rod, and are in a convenient and acces- sible position beneath the guides. The steam cylinders and heads are steam-jacketed and thoroughly lagged. The steam slide-valves are carefully and simply balanced. The double-acting water-plungers are hollow cylinders with tight heads, their weight being thus nearly floated, and the water entering the numerous suction-valves below them, passes them in a nearly direct line into and through the force-valves above. The valves are rubber disks, backed with iron, working vertically on fixed spindles. The engines, being horizontal, are accessible for inspection and repairs. Each engine drives its plunger at a speed uniform throughout its stroke, during which it opens, by a rock-shaft and appropriate connections, the steam-valve of the other, and is obliged to pause at the end of its own stroke until its own steam-valve is opened by the motion of the other piston.

INDICATOR DIAGRAM.
Taken from the rising main to reservoir.

The combined and reciprocal action of the two double-acting plungers is thus driven at unvarying piston speed by the combined pressures in the high and low-pressure steam cylinders (whose sum is a practically uniform quantity), which forces the water in a steady, quiet stream, as will be seen by the following indicator diagram, taken from the water main leading to reservoir.

The following are the principal dimensions of the cylinders, plungers, etc. :

DIMENSIONS.

Diameter of high-pressure cylinder in inches,	29
Diameter of low-pressure cylinder in inches,	50·25
Diameter of water-plungers in inches,	22·50
Diameter of piston-rod in inches,	4
Travel of pistons between cylinder heads in inches,	50
Diameter of air-pumps in inches,	20
Stroke of air-pumps in inches,	24
Number of air-pumps,	4
Number of high-pressure steam cylinders,	2
Number of low-pressure steam cylinders,	2
Number of water cylinders,	2
Number of inlet-valves in one cylinder,	16
Area of the 16 inlet-valves in square inches,	300
Number of outlet-valves in one cylinder,	16
Area of the 16 outlet valvés in square inches,	300

THE WORK TO BE PERFORMED BY THE BOILERS.

The water in Fairmount dam to be lifted into the reservoir on George's Hill, situated in Fairmount Park.

The following are the height, length and diameter of main, namely:

Height to top of overflow pipe in feet,	208
Length of pumping main in feet,	4167
Diameter of pumping main in inches,	30

MANNER OF CONDUCTING THE EXPERIMENT, AND EXPERIMENTAL DATA AND RESULTS.

Previous to the test the pressure-gages were carefully compared with standard test-gages, and a certified statement of their variations obtained.

The coal scales were tested and sealed by the official sealer of weights and measures.

The evaporation was determined by measuring the water in an open tank previously to its being pumped into the boilers, its capacity being 20 cubic feet; 19 cubic feet was the usual charge at intervals of about ten minutes. A float and gage-rod was provided and marked in cubic feet by actual measurement from a box exactly 12 inches square, and filled 12 inches deep. The correctness of the manner of measurement was verified at the commencement of the trial. As often as emptied, it was refilled through a pipe from the hot-well of the engine. From the tank, the water was forced into the boilers by a

small steam pump. The measurement of feed water was constantly in charge of an assistant, and every separate charge of water to the boilers was entered into a book kept for the purpose.

The total amount of water supplied to the boilers was 5212 cubic feet. A leak discovered at the commencement in the feed-pipe, which was carefully measured for a given length of time, and thereby the quantity lost was accurately arrived at, amounted to 40 cubic feet (temperature 139° Fahr., weight 61·52 pounds per cubic foot), reduced the amount of water evaporated to 5172 cubic feet, or 318,181 pounds.

The coal consumed was excellent anthracite, a first quality of steam coal, giving the very small residuum of about 10 per centum.

The coal and ashes were carefully weighed, one or more assistants being on duty in the fire-room during the whole test, and having a constant supervision thereof.

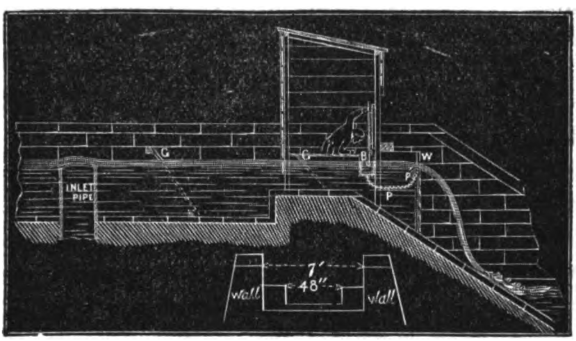
During the test the pressure of the steam per gage and temperature of feed water, which for this purpose was drawn from a cock in the pipe a few feet before entering boiler, were taken every twenty minutes. These observations were made by not less than three persons at the same time, and their notes carefully compared and verified as the test progressed.

The experiment was commenced at precisely 4.40 P. M., on Wednesday, May 15th, and continued until Friday, May 17th, at 5 o'clock P. M., being of forty-eight hours and twenty minutes duration. At the commencement a large clean fire was upon the grates; the steam pressure in the boiler was 48 pounds per square inch above the atmosphere by an American Steam Gage Company's gage; and the height of the water in the boiler was carefully noted on glass gages attached to the front head of each boiler, with tubes extending through the brickwork. At the close of the experiment the steam was left at the same pressure in the boilers, and the fires in the same state, as nearly as could be estimated, as at the commencement. The water in the glass gages at the close of the test was 0·17 inch lower than at commencement. The boilers are therefore charged with coal sufficient to bring the deficiency of water (530 pounds) from 129°.59, the temperature of feed-water, to temperature of steam, at 48 pounds pressure, 295° Fahr., or 10 pounds of coal.

The following are the experimental data and results:

Duration of trial in hours, ...	48·33
Mean temperature of feed water in the tank, in degrees Fahr., ...	129°·59

Mean pressure of the steam in the boiler in pounds, per square inch, above the atmosphere, ...	48·85
Total weight of water evaporated from a temperature of 129°·59 in pounds, ...	318,181
Equivalent weight of water evaporated from and at 212° Fahr., and atmospheric pressure, ...	352,676
Total weight of anthracite coal consumed in pounds,	40,330
Total weight of ashes, clinker and fine coal withdrawn from ash-pit in pounds, ...	4,349
Per centum of ashes, clinker and fine coal, . .	10
Pounds of coal consumed per hour per sq. foot of grate surface, ...	6·09
Pounds of combustible consumed per hour per square foot of grate surface, ...	5·63
Pounds of water evaporated from a temperature of 129°.59 Fahr., by one pound of coal, ...	7·88
Pounds of water evaporated from a temperature of 212° Fahr. by one pound of coal, ...	8·74
Pounds of water evaporated from a temperature of 129°·59 Fahr. by one pound of combustible, . . .	8·87
Pounds of water evaporated from a temperature of 212° Fahr. by one pound of combustible, . .	9·80



THE WEIR AT RESERVOIR.

The quantity of water discharged at the reservoir was measured over a weir, situated about 24 feet from the overflow of the delivery pipe in the flume, the crest of which was 8 inches lower than the mouth of said pipe, and the water flowing over it at an average depth of 9·2 inches. The sheet of water issuing from the pipe prior to the erection of the weir was about 4 inches deep. Considering all these conditions, the location of the weir was such that it did not obstruct

the flow of water from the pipe, neither was there such a fall from the pipe to the weir as to occasion any undue velocity in the flume. The flume was 7 feet wide; length of weir, 4 feet. The crest of weir was 5 feet above the bottom of flume, which sloped upwards from the weir towards the delivery-pipe.

To correct any inequalities in the velocity of the water approaching the weir, there were placed in the flume two fine gratings, *G*, about ten feet apart, equi-distant between the pipe and the weir, through which the water flowed before it reached the latter, and by this means an even, regular flow was obtained.

The depth of the water flowing over the weir was ascertained by a hook-gage, graduated to read to the one-thousandth of a foot, located about three feet up stream from the weir, supported by heavy timbers bolted to the masonry to avoid any danger of the gage moving out of its place after it was adjusted. The water in which the hook-gage was inserted was contained in a box communicating by pipes with the centre of a perforated pipe on the up-stream side of the weir extending nearly across the flume, in this way insuring the level of the water in the hook-gage box to be the same that would be due to the pressure of the water across the whole width of the weir.

The velocity of the water in the flume as it approached the weir was 27 of a foot per second. Mr. Francis's correction for this velocity would have added ·001 of a foot to the observed depth on the weir. The hook-gage when it recorded zero was accurately adjusted to be level with the crest of the weir at the commencement of the observations, by means of a graduated rule for that purpose.

The observations are recorded as running through 10 minutes, during which time two observations were made, and the average of these two was the depth recorded. The temperature of the water was noted at intervals, and in estimating the number of pounds of water pumped, the number of cubic feet of each recorded, temperature was computed.

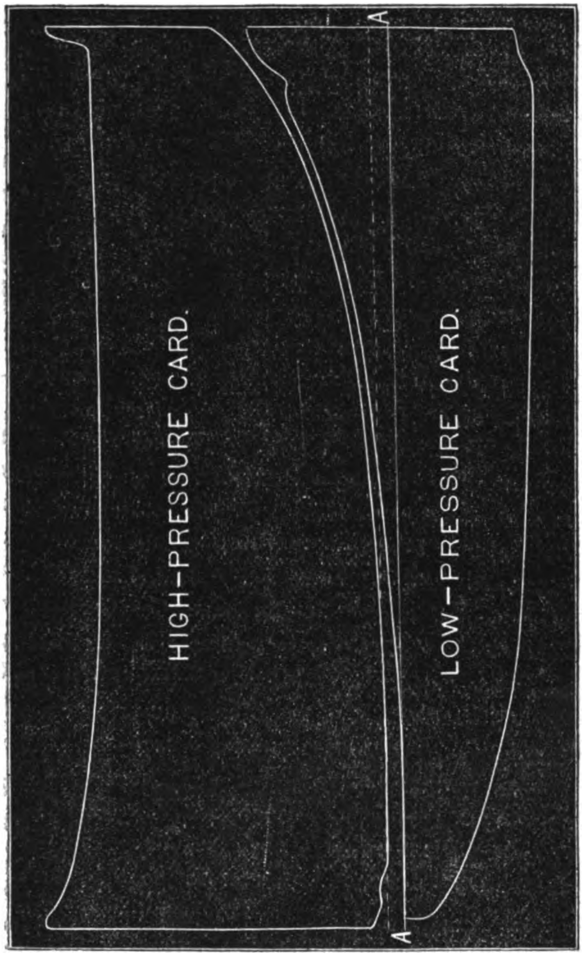
THE WORK PERFORMED.

By the above observations there was delivered into the reservoir, namely:

1. In twenty-four hours, in cubic feet,	747,047·45
2. " " " "	743,622·01
3. In twenty minutes " "	9,915·06
Total,	1,500,584·52

The same converted into pounds, at the average temperatures noted amounted to

1.	Twenty-four hours, in pounds,	46,539,325
2.	" " "	46,328,629
3.	Twenty minutes, "	617,559
	Total in forty-eight hours and twenty minutes,	93,485,513



Indicator Diagrams. From the Worthington Duplex Pumping Engine, taken during the experiments at Belmont. Scale 16 pounds to one inch.

RECAPITULATION.

Total weight of water evaporated, in pounds, in forty-eight hours and twenty minutes	318,181
Total weight of water evaporated, in pounds, in one hour,	6,583

Cubic feet of water evaporated in one hour, . .	107
Total weight of water elevated, in pounds, in forty-eight hours and twenty minutes, . . .	93,485,513
Total height of water elevated in feet, . . .	208

Having the amount of water evaporated in a given time, and the amount of water lifted to a given height, we can arrive at the horse-power of the boiler very readily :

$$\frac{93,485,513 \times 208}{48{\cdot}33 \times 60 \times 33,000} = 204 \text{ horse-power.}$$

The above result does not take into account the friction of the water through the pumps and main, nor that of the engines. The diagrams taken during the test, from the high and low pressure cylinders, amounts to 253·20 horse-power.

HORSE-POWER.

Per cubic foot evaporated, as per result.

Horse-power per cubic foot of water, including friction, .	1·90
Horse-power per cubic foot of water, as per indicator card,	2·48

It would seem, therefore, that the usual allowance regarding the amount of water evaporated per horse-power, viz.: one cubic foot of water, per horse power, per hour, is at variance with the experiments made at Belmont. The experiments made there were exceedingly close and precise. There is no doubt but the facts resulting from them can be implicitly relied upon; they show that the evaporative value of these boilers is equal to about 30 pounds of water per horse-power per hour, with a consumption of about four pounds of coal.

Philadelphia, January, 1873.

The Velocity of Light.—M. Fizeau, has lately published* the results of a series of very elaborate experiments, made with a view to the most accurate determination of the velocity of light.

The source of the ray was a jet of oxyhydric gas, and the distance between the two stations, as found by careful triangulation, was 33,827·1 feet, with a probable error of 0,001. Six hundred and fifty satisfactory observations were made, the mean of which, multiplied by the index of refraction 1·000 3 gave 185,386 miles per second as the velocity of light to an approximation of 0·003. This result agrees with that previously determined by Foucault, and also confirms the value of the sun's parallax (8″ 86), obtained by La Verrier.

* Les Mondes.

NOTES FROM THE UNIVERSAL EXPOSITION AT VIENNA.

(From our German Correspondent.)

Now, when the time appointed for the opening of the World's Exposition at Vienna is so near at hand, the attention of the public is naturally directed not only towards the Exposition itself, but also to the city of Vienna in general, while, on the other hand, the inhabitants of the latter are doing their very best to prepare for the reception of their expected visitors. Owing to the active zeal of all nations for representation in the Exposition, it assumes larger and larger dimensions, so that in spite of the very great area placed at the disposal of the exhibitors, the complaint of insufficient space has become permanent. That part of the Exposition especially which is to represent the German Empire will be very extensive. The space reserved for Germany within the Palace of Exposition is far from sufficient, and the German Commission have therefore erected several large pavillions between the Industrial Palace and the Machine Hall. The extremely mild winter favors the uninterrupted continuance of all kinds of work without any difficulties, and it can hardly be doubted that the Exposition will be opened at the appointed time and with all the arrangements completed. My former assertion regarding the insufficiency of light in the Palace of Exposition I still maintain, however, especially as far as the Rotunda is concerned, although the official organs of the press endeavor in every way to bring light into this darkness.

As regards the city of Vienna itself, its authorities have to provide, before all other things, suitable public conveyances. For this purpose several new omnibus and horse car lines have been organized. A belt-railroad for locomotives, which had likewise been planned, has however, thus far not been built. But the mountains *Kohlenberg* and *Leopoldsberg*, in the immediate vicinity of Vienna, which offer beautiful prospects and favorite pleasure grounds for excursions, have been connected by two roads, a rope-road and a road with a toothed rail, after the model of the Rigi and Mt. Washington road. For the planned belt-road and for similar narrow gauge roads, engineer Mannhart, of Vienna, has constructed a locomotive which possesses essential advantages, and has been tested already with the greatest success. The subjoined drawing (Fig. 1) furnishes an illustration of this engine, of which the following is a description.

Mannhart's locomotives are all tank engines, and are, compara-

tively, of enormous power. 1st. Locomotives for industrial, forest and mountain railroads of from 0·632 meters, equal 24 Vienna inches gauge. Two pair of coupled wheels of 0·800 meter diameter, the rear pair of which is on the driving axle, with a wheel-base of 1·500 meters, are below the boiler in front of the fire-box. Both drivers can be braked in front. The brake-spindle is placed at the railing around the footboard. The cranks and bearings of the wheels are after Hall's system, the manner in which the weight is distributed and in which the springs are applied is especially favorable. The two outside cylinders, which are 1·432 m. apart between centres, have a diameter of 0·240 m.; the stroke of the piston is 0·425 m. The boiler, with a diameter of 0·800 m., contains 88 tubes, of a length of 2·540 m., with an outside diameter of 0·046 m. The total heating surface is 34·375 square m.; that of the fire-box 2·792 square m.; that of the grate 0·545 square m. The ratio between the direct and the total heating surface is consequently as 1 : 12·3; the ratio between the grate and the heating surface is as 1 : 63, an extraordinarily favorable one, which presupposes the great power of the machine and very great economy in the consumption of fuel. Moreover, the total weight is subservient to adhesion. The copper fire-box roof is stay-bolted to the iron one, after L. Becker's system, which lessens the overhanging weight of the fire-box, which is 0·810 m. long (the front of which is 0·440 m. distant from the centre of the driver), and avoids too great an elevation of the fire-box, thus favoring a better lookout.

The cubic contents of the water-tank is 1·5 cubic m., and that of the coal bunker 0·75 cubic m. The water tanks are partly at the side of the barrel of the boiler and partly under it, between and above the axles in the form of a cross. The sand-boxes are on both sides of the frame. A dome of a diameter of 0·500 m. is placed near the front of the barrel of the boiler, which is riveted together in only two sections, and contains a safety valve and the regulator. The rear safety-valve, the whistle, the injector-cock and the pressure gauge are placed upon a small cast iron dome, with a diameter of 0·210 m., whose whole arrangement must be pronounced as very ingenious. Blast-pipe, blow-off cock, the manhole and water-gauge are arranged in the usual manner. The stack is conical, with Klein's spark arrester.

Stephenson's link motion is placed outside. The eccentrics are fitted on return cranks of the driving axle; the steam chests are

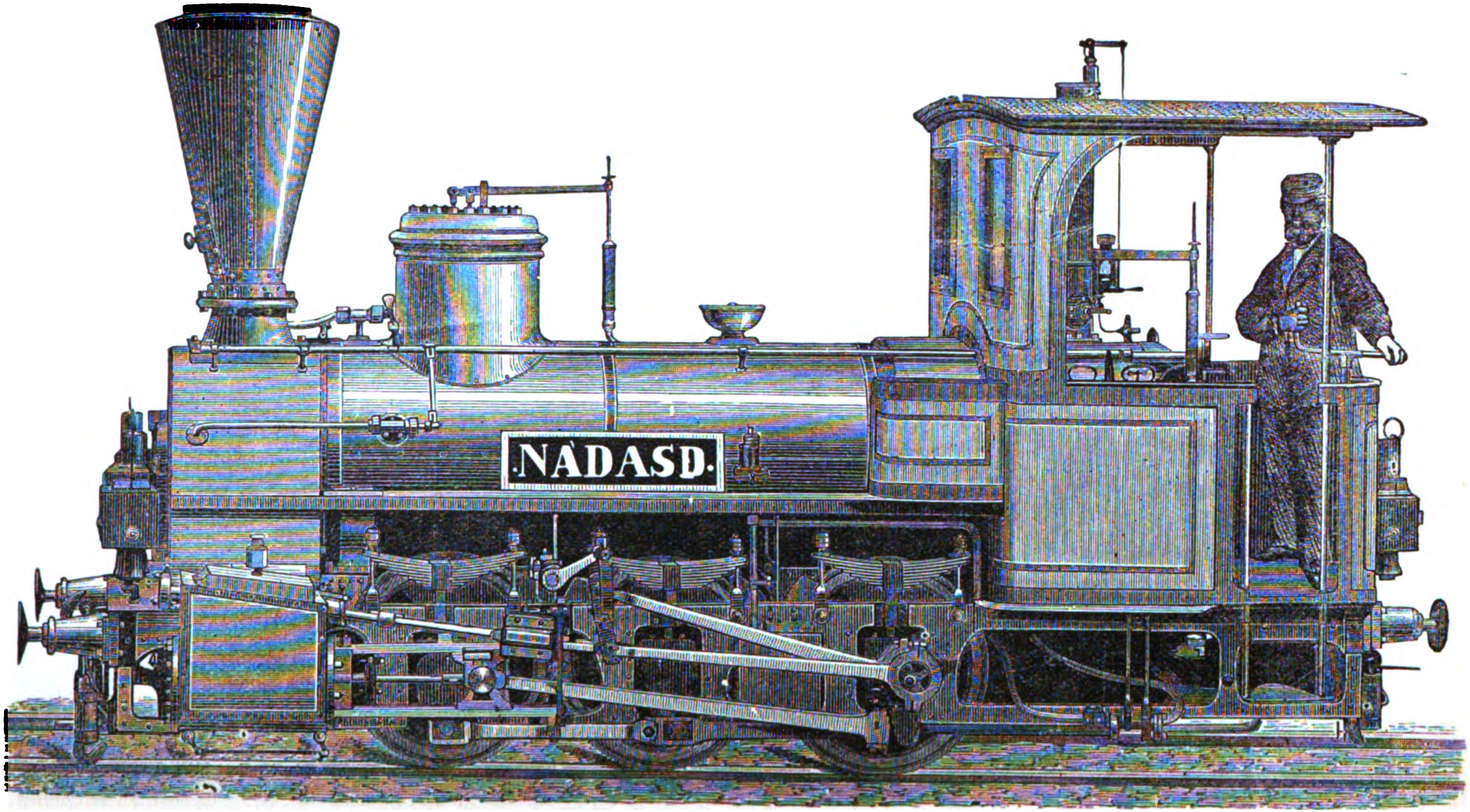


Fig 1.

placed obliquely upon the steam-cylinders; the length of the eccentric rods and of the connecting rod is considerable and very favorable. The valve stem is guided in the slot link by a guide fastened to the bracket of the crosshead guides and by the two stuffing boxes of the steam chest.

Drawing hooks, buffers and railguards are symmetrically placed at both ends on iron cross plates. The foot board behind the fire-box is 1·800 m. wide and 0·750 m. long. The former (1·800 m.) is also the measure of the greatest width of the machine, whose length is 5·630 m. The distance from the front axle to the buffer-end is 1·700 m., from the driving axle to the rear buffer-end 2·340 m. The greatest height of the stack above the rails, 2·800 m., and that of the top of the boiler, 1·600 m. The usual cab rises from the foot-board. The feeding of the boiler is accomplished by means of two of Friedmann's injectors symmetrically applied. The weight of this machine when in service is 10 tons.

2d. *Three-Driver Locomotive for a gauge of* 0·750 *m.* This locomotive has three pair of coupled wheels, whose rear one is the driving wheel. The general arrangement is exactly the same as that of the one previously described.

Greatest length of machine,	5·930 m.
Wheel base,	1·800 m.
From after end of engine to centre of driving wheel,	2·340 m.
From front end to centre of front axle,	1·790 m.
Distance of axles,	0·900 m.
Diameter of cylinder,	0·290 m.
Stroke of piston,	0·425 m.
Diameter of wheels,	0·800 m.
Total heating surface,	38·380 s. m.
Direct " "	3·070 s. m.
Grate surface,	0·639 s. m.
Grate surface to heating surface,	1 : 60
Direct heating surface to total heating surface,	1 : 12·4

88 tubes 2·840 m. long, with an outside diameter of 0·045.

Distance between centres of cylinders,	1·550 m.
Width between frames,	1·050 m.
The wanter-tanks hold	1·75 c. m.
Fuel space,	0·85 c. m.

Weight of engine when empty, ...	12 tons.
Weight when in service (at the same time weight of adhesion), ...	15 tons.
Pressure of steam, ...	10 atmospheres.

3d. *Locomotive with* 8 *coupled wheels for a gauge of* 0·750 *m.* Has four pair of coupled wheels, the last but one being the drivers.

Greatest length of engine, ...	6·435 m.
From end to rear axle, ...	2·340 m.
Distance between centres of adjoining axles, . .	0·760 m.
Total wheel base, ...	2·280 m.
From front axle to end, ...	1·815 m.
Diameter of cylinder, ...	0·320 m.
Stroke of piston, ...	0·425 m.
Diameter of wheels, ...	0·760 m.
104 tubes 3·300 m. long, of an outside diameter of .	0·045 m.
Total heating surface, ...	52·25 s. m.
Surface of fire-box, ...	3·75 s. m.
Grate surface, ...	0·888 s. m.
Ratio of grate surface to heating surface, . .	1 : 59
" " direct to total " " . .	1 : 14
Steam pressure, ...	10 atmospheres.
Water-tanks, ...	2·25 c. m.
Weight of empty engine, ...	17 tons.
" in service (weight of adhesion), . .	22 tons.

The last two kinds of engines have the brake invented by Mannhart. The brake-blocks are placed above, between the wheels, on a shoe guided by the boiler supports. They are worked by a lever, connected with them by a link. The spindle lies horizontally; the effect is almost instantaneous, since the brake-blocks, when pulled, press the middle wheels not only to the boxes, but also to the rails. The outer wheels are pressed only to the boxes; a possibility of running off the track is thereby avoided.

There is no doubt that these engines can be furnished at less expense by omitting Hall's system. To be sure some water room is lost by the greater narrowness of the frames, and the motion loses some of its ease; but since the water room is still sufficient for short distances, and since no greater rates of speed are wanted, the transferring of the frames within the wheels might recommend itself. Such machines are at present built in the factory of the Forest &

Mountain Industrial Company, at Mœdling, near Vienna, and have already before been built in the machine works of G. Sigl, in Vienna.

The following table shows the capability of these locomotives in hundred weights (= 50 kilog).

Grade.	For two-drivers.		For three drivers.		For four-drivers.	
	from cwt	to cwt.	from cwt.	to cwt.	from cwt.	to cwt.
1 : ∞	4800	5400	6500	7500	10460	13500
1 : 500	3200	3800	5200	6000	7600	9500
1 : 300	2800	3200	4400	5000	5960	7800
1 : 200	2200	2600	3600	4000	4760	6500
1 : 150	1800	2000	2900	3300	3900	5100
1 : 140	1700	1900	2800	3200	3750	4900
1 : 130	1650	1800	2600	3000	3600	4700
1 : 120	1580	1700	2500	2900	3400	4500
1 : 100	1500	1600	2100	2400	2960	3900
1 : 80	1200	1300	1800	2100	2420	3200
1 : 60	850	1000	1380	1600	1880	2500
1 : 50	680	820	1100	1300	1560	2000
1 : 40	520	600	900	1100	1200	1600
1 : 30	350	460	620	740	840	1200

For railroad construction the factory of G. Sigl, in Vienna, has likewise built a very convenient locomotive, which is at the same time provided with a contrivance that allows it to be transported on ordinary roads. This locomotive (represented in Figs. 2 and 3) has received the name of *portable locomotive*. It is a four-wheeled tank engine, of normal gauge, has a short wheel base, in order to be available for sharp curves, and buffers, the height of which, from the rails, can be changed. At both sides of the boiler water-tanks are attached; both pair of wheels are coupled, and the brake is between the wheels. Fig. 2 shows the locomotive ready for service. For transportation on ordinary roads the front wheels are bound with cast iron tires, the construction and fastening of which may be inferred from Figs. 4, 5 and 6. Under the platform a carriage with an ordinary wagon-pole is fastened, while the rear wheels of the locomotive are raised from the ground.

Fig. 2.

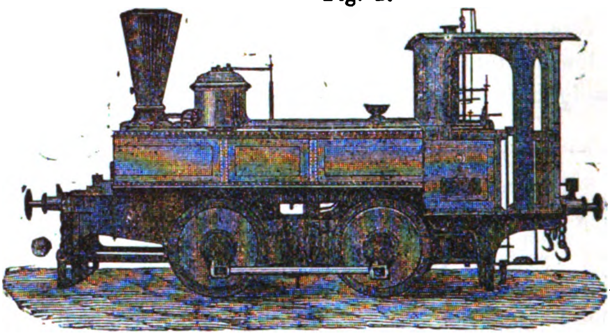


Fig. 3.

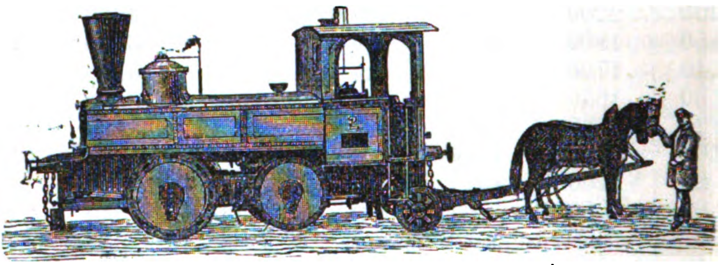


Fig. 6.

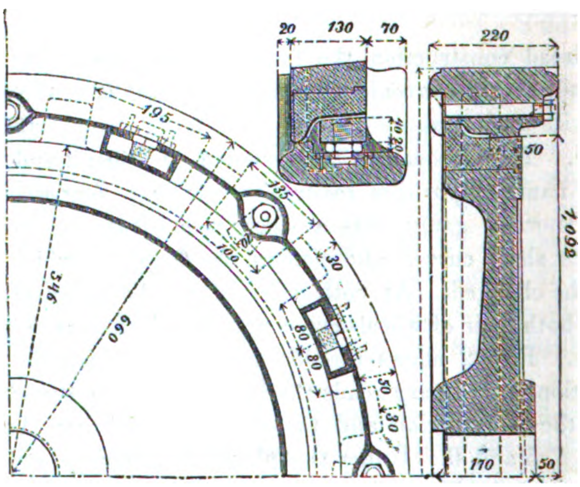


Fig. 4. Fig. 5.

This locomotive, as well as the apparatus for transportation, have been found very serviceable, and they are in constant demand. Its main proportions are as follows:

Weight of machine in service, ...	18 tons.
" " " when empty, . . .	15 tons.
Diameter of driving wheel, ...	1·100 m.
Total heating surface (with 84 tubes), . .	38·867 s. m.
Heating surface of fire-box, ...	3·242 s. m.
Grate surface, ...	0·523 s. m.
Diameter of cylinder, ...	0·265 m.
Stroke of piston, ...	0·500 m.
Performance on $\frac{1}{\infty}$ with $2\frac{1}{2}$ (German) miles per hour, exclusive of machine, ...	6500 cwt.

The same firm have made a blowing engine for blast furnaces, of which I subjoin a photographical representation, and which is distinguished by many interesting details of construction. Two such engines were made for the Schwechat Iron Works. Each machine furnishes the blast for a furnace that melts 1200 cwts. of iron per day. The engine is of the compound condensing type, and has a poppet valve motion. The small steam cylinder has a diameter of 33″ and a stroke of piston of 6′ $10\frac{3}{4}$″; the large steam cylinder 100″ diameter and stroke of 9′ (all in Vienna measurement). The valves for the blowing cylinder have a circular arrangement. The throttle-valve for the regulation of the blast is new and interesting. It consists of two cones inserted into a globe-shaped chamber of the conducting pipe, which are, by means of a screw spindle, that has a right and left hand thread, removed from one another when the blast is to be shut off, and to be brought near each other when the blast is put on.

A street locomotive by the same firm is also very ingeniously constructed, but somewhat too heavy for ordinary streets. This locomotive has two separate engines, each of which drives a wheel.

I have to mention as another novelty a governor, invented by Dr. R. Proell, Engineer, which is specially distinguished by its simplicity. Whether it possesses the advantages that have been claimed for it and theoretically proved, must be demonstrated by experience derived from its practical application. At all events its pleasing form and convenient arrangement would recommend it even if it should not possess *all* the eminent advantages claimed for it by the inventor. The following description will enable experts to judge for themselves.

As the wood-cuts in Figs. 1 and 2 show, Dr. Proell's governor is to be considered as an improvement on Porter's governor. The ball

Fig. 1.

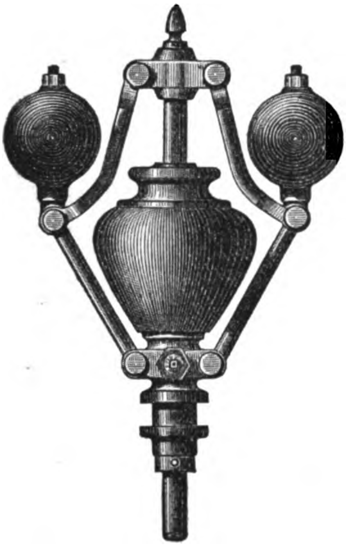
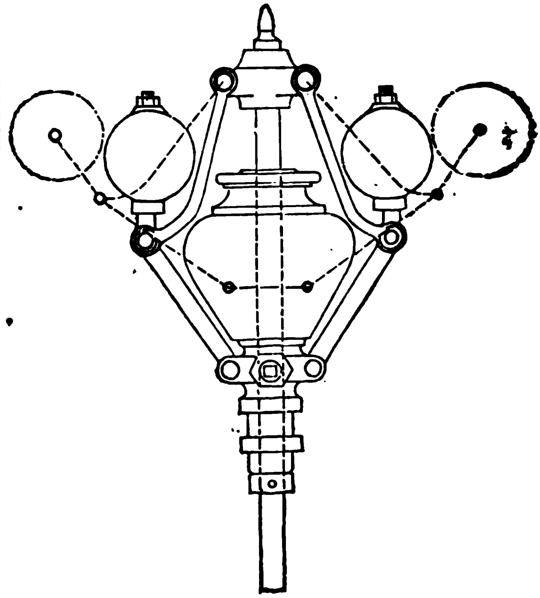


Fig. 2.



is taken from the joint and placed upon a separate arm, which forms a definite angle with the lower connecting link. The angle BDE is a stationary knee-shaped piece, which, in the upper position of the governor in Fig. 4, occupies the position indicated by the dotted lines. By this change in the position of the balls, Porter's governor, in which the balls swing in a circle around the stationary points at C, has been made pseudo-astatic, *i. e.* the sleeve accomplishes its way, which lies between the extremes of 50 mm. and 75 mm., no longer with great changes of velocity (10—15 per cent.), but with comparatively small changes of velocity (2—4 per cent). The ball-centres in Proell's governor move in a circle whose centre lies at more than double the height on the other side of the spindle, pretty nearly in *a*. Since the effect of external forces upon a governor is independent of the manner in whch the ball-centres are led in appropriate orbits, it is evident that the working of this modification of Porter's governor is nearly identical with that of a governor in which the dotted lines, AB, are actually carried out as rods, and the ball-centres, B, are led in a circle around A.

Fig. 3 shows the hitherto usual construction of pseudo-astatic governors with crossed arms; figs. 2 and 4 the change in the connection of the joints devised by Proell.

Fig. 3.

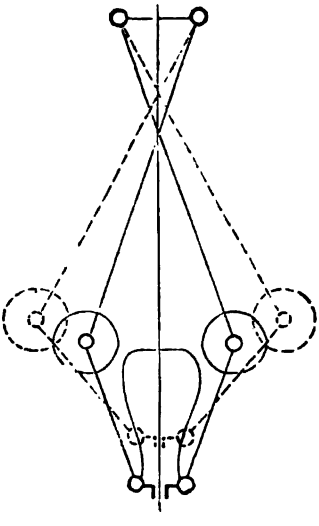
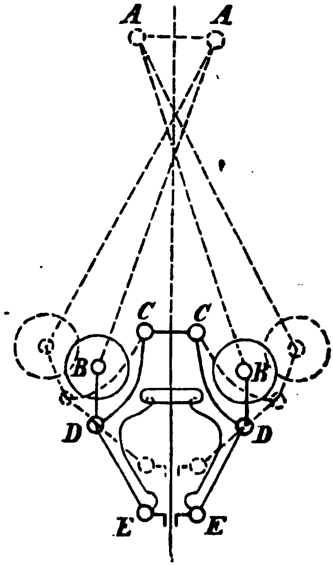


Fig. 4.



A comparison of the two constructions represented in figs. 3 and 4 shows, in the first place, that the total height of the governor, which, in consequence of the crossed arms, is considerable, is diminished by one-half in Proell's governor (fig. 4). The entire length of the spindle is very small, and, therefore, its journal requires only a box of small height. A prolongation of the spindle beyond the stationary points, C C, will, even with very large governors, not appear as necessary.

By inserting the angles E D B, as well as by judicious bending of the upper arms, C B, there is, moreover, a comparatively large space gained for applying a heavy counterbalance, and it becomes possible to fasten large balls on the projecting arms. Upon the weight of the parts of the governor depends its capacity for work. Since now the masses in Proell's governor, in spite of its compendiousness, are very considerable (in the governor marked as III in the subjoined table the balls and the counterbalance alone weigh 54 kg.), it has also a considerable capacity for work, *i. e.* it works very energetically. But Proell's governor excels by still another advantage other governors, in consequence of the compendious arrangement of the joint-connections. At a sudden change in the velocity of the governor the balls, in consequence of their inertia, have the tendency of leaving the plane in which the joints are connected.

The greater this tendency, the stronger is the so-called "edging" and the "wear and tear" at the forks of the suspended arms. Since now the latter in fig. 3 are considerably longer than in fig. 4 the forementioned inconvenience of "edging" and "twisting" will be considerably more diminished in Proell's governor than by the hitherto usual construction of governors with crossed arms, since the respective forces in the former case work through much shorter lever arms. In the latter case the disadvantage to the working of the governor, arising from the "edging" and "twisting" of the joint-connection, may be removed, to be sure, by making the arms stationary at the spindle above the urn, but this produces a greater friction in the moving parts, which again considerably diminishes the sensitiveness of the governor.

The manner of fastening the balls on the projecting arms of the lower connecting links, which is peculiar to Proell's governor, allows an increase or decrease of the distance between the ball-centre and the middle joint by substituting for the little disc lying underneath the ball, a higher or lower one.

In proportion as the distance is increased or diminished the approach to the astatic condition is likewise effected. In the governor, IV, in which the "sleeve," during a change of velocity of 3 per cent. (without regard to resistance), performs a stroke of 75 m. m., the height of the little disc underneath the ball is 12 m. m. If this is replaced by one twice as high, the total increase of velocity is 2 per cent.; if the disc is entirely removed it only amounts to 4 per cent. The approach to the astatic condition is, therefore, doubled with reference to the extremities of the balls. It is possible, therefore, by merely changing the discs under the balls, to ascertain for every given case by experiment the height of the situation of the balls which corresponds to the most favorable working of the governor; but since at the same time also the number of revolutions of the governor changes within definite limits, a displacement of the balls may be made a means of adjusting the machine for another number of revolutions. At a mean position of the ball, for example, the governor, IV (in the table), makes in the average, without regard to the resistance of friction, 81 revolutions; at the lowest position of the balls (12 m. m. lower) 83; at the highest (12 m. m. higher) 79 revolutions.

Finally, it is to be mentioned that very considerable masses may be disposed of in Proell's governor without causing their construction

to exceed the practicability of execution. Governors, the total height and greatest width of which amounts to only one meter, have a mass of about four cwt., and are, therefore, adapted to a high degree to be used in all those cases in which the regulation of the motor requires a considerable expense of work, as, for example, on water-wheels and turbines for the direct movement of the sluice, and on steam engines where the expansion valves are to be directly moved by the governor. Geometrically all governors resemble each other. On examining the sketch given in fig. 4, which is drawn in three-eighths, three-twentieths, one-fourth, three-fourteenths of the actual size, it will be found to represent the proportions marked as I, II, III, IV, in the subjoined table.

That the number of revolutions of Proell's governor is comparatively a small one must be pronounced as not unessential. For with governors of a great number of revolutions the arrangement for increasing the velocity has often its inconveniences. Likewise the lost motion in the adjusting apparatus, arising from wear and tear, has no great injurious influence upon the manner of working of the governor, because the elevation of the sleeve according to the size, vacillates between 50 and 75 m. m., *i. e.* convenient values. The excellent working of Proell's governor has already, practically, been established, and observations and experiments have demonstrated that the value of a change in the motion of from 3–4 per cent. for the total elevation of the sleeve which underlies the constructions is the most convenient approach to the astatic condition.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

A regular meeting of this Society was held at the rooms in New York, February 19th, 1873.

The Secretary presented the following discussion of a paper "upon the character and position of neutral axes as seen by polarized light," by Louis Nickerson, C. E., of St. Louis, Mo., read before the Society December 18th, last.

COL. MERRILL.—This paper opens a field for examination which promises the most useful results in a matter of vital interest to engineers:—the laws of strains in materials used for construction. The plan of using glass to find out these laws, brings to mind the practice of physicians in ancient times of determining the laws of the human body, by experiments upon those of the lower animals.

In examining the action of strains within opaque bodies, the method by analogy seems to be the sole one—aided, of course, by what is visible on the surface and detected after fracture.

Further experiments will probably enable us to decide with fair accuracy what is the magnitude of an unknown strain on a glass column, by comparison with the observed effects of a known strain upon a similar column.

The proposed strengthening of tubes by external rings at regular intervals, is a curious result of the experiments, and—if confirmed by practice—a valuable discovery. The whole discussion illustrates the interdependence of all branches of physical science; and that no discovery is to be considered useless, no matter how far it is apparently removed from a practical application.

Mr. McAlpine.—The civil engineer has rarely to deal with glass as a material of strength; still, evidently, it will be affected in the same way as any similar material—as cast iron. It is a characteristic of this age, that every discovery in science is made useful to the engineer or constructor.

Some years ago, Prof. Airey devised a system of measuring the strains in each member of a truss, with a model in steel, of which he had exact duplicates. When the model was loaded, a member was struck, and the strain upon it measured by the load borne by the duplicate when in accord. There we have *sound*, and here we have *light*, to aid in solving an important problem.

Gen. Ellis.—Westheim, of Paris, invented an instrument for the determination of strains and pressures by the colors of polarized light. Mr. Nickerson's examinations are in the right direction, and it is hoped he will pursue the matter further.

What we want to know is, the elastic resistance to tension and compression in any one substance, and the effect of a weight upon a beam of the same substance; then knowing, by experiment, the elastic resistance in both directions of other substances, we reason upon the position of the neutral axes of beams made therefrom.

Writers upon the strength of beams err in assuming that equal strains extend and compress the same substance equally, (thereby locating the neutral axis of horizontal strains in the middle of a rectangular beam;) also, that the elastic and ultimate resistances are proportional.

How can polarized light show a neutral axis in a glass beam, supported at the ends, and weighted in the middle, instead of a neutral

point under the weight? Everywhere in the beam except at the central point, there are diagonal strains, which will, as well as the horizontal strains, transmit the polarized rays.

The additional element of strength referred to in the paper, is, I think, due to the elastic yielding of fibres which, in consequence, slip upon each other, without a diminution of their ultimate strength. Otherwise, in a beam under strain, the outer fibres would be ruptured before the others were loaded.

A communication from Gen. Smith, chairman of the committee appointed at the annual convention, held in Chicago, June 5th and 6th, last, to urge upon the United States Government the importance of a thorough and complete series of tests of American iron and steel, and the great value of formulæ to be deduced from such experiments, was read, stating that information is required of what has been done in this direction by other Governments, as well as by corporations and individuals here and abroad; of new forms employed, and of new processes of iron and steel-making, and their products.

A paper by Gen. W. S. Smith, of Maywood, Ill., on "Pneumatic Foundations," was read.

The first two bridges on pneumatic pile foundations erected in the United States, were one over the Santee River, on the Northeastern Railroad, built in 1855, and the other over the great Pedee River, on the Wilmington, Columbia and Augusta Railroad, built in 1857.

The air-lock used in sinking these piles, was invented by Alexander Holstrom. It was a cast-iron cylinder, six feet in diameter and four feet high—closed at top and bottom by cast-iron plates, through which were man-holes opening downward for entrance, and bull's eyes of glass for light; two goose-neck pipes passed through the sides and bottom—one for introduction of air, and the other for the discharge of water when it would not escape through the material underneath the pile. A windlass was attached for raising the earth within the pile, all of which was removed by hand.

There were four air-pumps, set in a single frame, of such excellent construction that they served for the sinking of their foundations, those of the Third Avenue Bridge, New York, across Harlem River, and of the Leavenworth Bridge across the Missouri River, and are now being repaired for use in sinking the piles for the Little Rock Bridge across the Arkansas River.

Construction of the pneumatic pile piers for a bridge over the Savannah River, on the Charleston and Savannah Railroad, was begun

in the fall of 1859. The air-lock used was six feet instead of four feet high, and, to save weight, the cylinders of wrought instead of cast iron. Two defects were soon apparent: one, practically no natural light was admitted into the pile through the bull's eyes in the air-lock plates; those in the bottom being covered with dirt most of the time: another, the air-lock was too small to stow the material raised, so that when discharging the same, work in the pile was much delayed.

To overcome these defects, an air-lock was made of less diameter than the pile, so that an annular space was left between the two, in the plate covering the top of the latter, into which bull's eyes were introduced. Through the side of the air-lock was a pipe or trap, inclined at an angle, to discharge readily any material put into it, and arranged for closing at either end. The outer end being closed, the trap was filled with material; the inner end was then closed, the compressed air, thus cut off from the air-lock, liberated, and the outer end opened—when the material would pass out. By reversing the process, the trap was made ready to receive material again.

By this modification, no artificial light was required during the day, and at night it could be reflected into the pile without the inconvenience of candles or lamps burning in a compressed atmosphere. No detention occurred from this or from voiding the material raised, and nearly thrice as much work was done in the same time as with the Holstrom air-lock.

It was soon found that the sandy material through which these piles were sunk, could be raised by the escaping compressed air, through a discharge pipe, and delivered outside in a continuous stream. For this, the mouth of a flexible tube, fitted to the lower end of a fixed pipe, was thrust into the wet sand, and moved from place to place, as the material disappeared. The ratio of work done to that with the old air lock, which before was as 28 to 10, now became as 28 to 1.

The improvements thus introduced have been generally used since by Gen. Smith in sinking foundations by the pneumatic process. For the flexible tube, one iron pipe sliding into another, with a hempen gasket between, has been substituted, with the still better results. Thereby seven men have excavated six cubic yards per hour, for several hours. By hand, two-thirds of a cubic yard per day per man is about the rate.

The late war interrupted this work, and also prevented consideration of a plan submitted to the U. S. Light House Board in 1860, for

the erection of a light house on Frying-Pan Shoals, or a similar position on the coast, embracing the sinking of a caisson from thirty to fifty feet in diameter, to any required depth less than one hundred feet; inside of which a masonry foundation of dove-tailed stones was to be laid. Soon after the war the plan was adapted to the repairing of Waugoshance Light House, located at the western entrance of the Straits of Mackinac, upon a rocky reef two-and-a-half miles from shore. It is a brick tower of twenty-four feet in diameter, eighty-four feet high from water surface to focal plane, and stands upon a foundation twenty-four feet square, consisting of a crib, filled with concrete and rubble masonry. This crib was surrounded by others filled with loose stones, all framed together into one pier one hundred feet square. At this time the timbers put in place in 1848 were decaying under the action of seas, as heavy as any upon the Northern lakes, and the ice. The utter destruction of the pier was threatened.

It was proposed to protect the tower from waves and ice by surrounding it with a strong sea-wall sixty-six feet long and forty-eight feet wide on the outside; eight feet thick, and semicircular at the ends. An annular pneumatic coffer-dam of boiler iron was built up in place around the tower large enough to enclose the wall. It was provided with two air-locks, each having a rectangular trap, through which material and workmen passed, and a windlass driven by steam. The dam was suspended by chains from beams resting upon the woodwork of the old pier, and with stones loaded somewhat in excess of its buoyancy. For six feet below the water surface, the crib timbers of pine, twelve by twelve inches, built up solid, and strongly drift-bolted with round one inch iron bolts, had to be cut through. The reef then reached was made up of boulders varying in size from a hen's egg to ten tons weight. The large ones, when found under the edge of the caisson, were first split with plugs and feathers, or undermined, drawn into the caisson, and then split. In some instances, where large stones rolled against the dam and kept it from sinking, the dam was allowed to raise, and the stones were rolled inward.

The dam was sunk to the depth of 12½ feet below the water surface, and six feet below the foundation of the tower, which, though not upon bed rock, as expected when the work was begun, was where the boulders (which had lessened in size as the depth increased) were most perfectly compacted together, and below the scouring action of the waves, from which the dam was protected by the remaining portion of the cribs. The bottom of the dam was then sealed with two successive

layers of the quickest setting Louisville cement, each six inches in depth, and set under water, which, when the air pressure was reduced, entered through holes left for it in the layers.

It was found the twelve inches of cement thus laid, would not, after four days' setting, resist the pressure of water outside, hence the first three courses of masonry, each two feet thick, were laid in a compressed atmosphere. The stones were dowelled together with iron pins 2½ inches in diameter; the end of each pin was drilled one inch in diameter, three inches deep, and sawn, so that when in place and a taper bolt driven therein, the dowell was permanently enlarged.

When the wall was finished, the space between it and the tower was filled with concrete, and covered with flagging. The coffer-dam, which might have been removed for use elsewhere, was left in place.

Work could only be done in the months beginning with May, and frequently it was interrupted by storms. During the first season the chamber to receive the dam was excavated; the machinery was put in place; the dam built and sunk four feet. During the second season, the sinking was concluded, and seven courses of masonry laid. And during the third season, the work was entirely finished. An average force of forty men was employed. The entire cost, including a new dwelling for the light-house keeper, was less than $200,000. This is the first instance of the sinking of a pneumatic coffer-dam or caisson in this country.

After the completion of this work, Gen. Smith, in 1869, proceeded to put down at Omaha, for a bridge across the Missouri river, the first pneumatic piles sunk west of the Alleghany mountains, and to a depth greater than ever before reached—eighty-two feet below the water surface. The material was very difficult to penetrate. It consisted of a fine silt, stratified with layers of coarse sand and tough blue clay—the latter not more than two feet deep, and with a stratum of pebbles or gravel one and a half to two feet deep next to the bed rock.

The first pile went down vertically; the second, after sinking twenty-seven feet, took an inclination which could not be corrected in the next twenty feet by the various means applied, which, although they failed here, in many other cases have succeeded at a depth of from forty to fifty feet. Generally, the most effective method is to excavate the material under the pile, and, with heavy wooden wedges, firmly wedge up the lowermost edge; then, by letting the air escape suddenly, bring the atmospheric pressure and the weight of the pile to bear like a blow. In this case the silt came in so rapidly as to carry the wedges before it.

Another cylindrical section was put in place, thus adding ten feet to the length of the pile, making it sixteen feet, and, with the air-lock, twenty-two feet above the earth surface. A strong frame of twelve by twelve inch timbers was laid down for a fulcrum; blocks and falls were attached to the air-lock, and a severe strain was put upon the pile. The material was again excavated, and, instead of the wedges, a strong beam, cut to the segment of a circle, put down. The pressure was let off, and the pile descended, but without any correction of the inclination, although the timbers of the fulcrum were broken.

A pine strut, eight by eight inches, eleven feet long, was set at a slight angle—its top against the leaning pile, and its foot against the pile already in place, without avail, and at last the cylinder broke off twenty-seven feet below the surface, where there was a "cold shut" in the metal.

With fifteen feet of sand in the cylinder, forty-five pounds air-pressure to the square inch, did not lift the piece broken off; but twenty-seven pounds were sufficient after the sand was removed.

This is the only opportunity he has had to measure approximately the friction on a cast-iron pile. The friction per square inch of surface in contact, before the sand was removed, was greater than 1·77 lbs., and after it was less than 1·39 lbs. This friction must vary with the depth of material, and is diminished when the earth is loosened by the passage of air currents through it. The case instanced differs from that of a pile in place under a load. An important subject of inquiry is—What should be taken as the safe resistance of such a pile, in sand, to sinking alone? Where no bed rock can be reached, as along the lower Mississippi, and on the Gulf coast, it may be desirable to sustain structures upon piles or caissons, resting wholly in and on sand.

The next two piles were put down without great difficulty—one at the rate of ten feet per day. To cause the piles to sink, they were loaded by filling the cylinders with stones, except a central passage, or well-hole. Frames built within the cylinders, kept the stones in place. After a certain depth was reached, it was necessary to increase the downward pressure on the pile, by allowing a portion of the compressed air to escape; the pile would then sink from two to four feet at a time. The top of the bottom cylinder was covered with a cast-iron diaphragm, through which there was a manhole, closed by a valve opening inward, which, when shut, prevented more sand from entering the pile, while sinking, than would fill the lower cylinder;

thereby the tendency to "lurch," and the disturbance of outside material, was lessened.

At this stage of the work, Gen. Smith was succeeded by Mr. Theo. E. Sickles, who successfully employed levers in forcing the piles down, and corrected the inclination by drilling holes through the higher side, at different heights, through which the compressed air escaped; loosened the outside material, and thus lessened the friction against the pile.

Gen. Smith then sank the piers for the railroad bridge across the Missouri river at Leavenworth, Kansas—three in number (two in the river and one on the east bank)—upon which, and a stone abutment, three spans, each 340 feet long, were erected. This was finished in two years after its commencement. The difficulties encountered were similar to those of Omaha.

The following conclusions are deduced from an experience of fourteen years in sinking pneumatic pile foundations:

1st. The greatest difficulties to be overcome are, first, in keeping the pile vertical; for this it should be made to follow the excavation without a reduction of air-pressure: and, secondly, in "righting" the pile when inclined; for this, wedging under the bottom, or propping the top on the lowermost side, and drilling through the uppermost side, are the best means yet tried.

2d. The "air-lift," as described, is the cheapest and most efficient method of removing sand or mud from within a pneumatile pile or caisson.

3d. A strong and reliable pier can be always built of pneumatic piles—their number, diameter, and the thickness of metal being determined by the conditions of the case.

4th. In cold climates, these piles may be fractured by frost—to prevent which, a filling below the frost line, from two to five feet deep, of asphaltic concrete, is recommended.

5th. Where suitable timber and stone are to be obtained at reasonable prices, a single pneumatic caisson can be sunk with greater certainty and at less cost, than a pier of three or more pneumatic piles, where it has to be sunk for a considerable depth through a soft material to a hard one. A pier of masonry on such a wooden caisson, cellular, with its walls well drift-bolted, and its interior carefully filled with concrete or rubble, is the cheapest and best bridge foundation yet devised.

6th. Concrete does not "set" well under air-pressure. The water

was let in through a pipe inserted therefor in the cement, to cover the successive layers as put down. Usually, cement, five feet in depth, would seal the pile; the remainder was added in the open air.

DISCUSSION.

MR. MARTIN.—The first work he had to do in sinking the pneumatic pile piers for a bridge across the Savannah river, on the Charleston and Savannah Railroad in 1861, was to straighten up a cylinder which was about thirty feet in the sand, and considerably inclined. The method described by Gen. Smith, of excavating underneath the lowermost edge of the pile, wedging it up firmly, and then, when severely strained in the right direction by strong tackle, causing the pile to go down by suddenly letting the pressure off, did not succeed, although the pile descended two feet or more. He then excavated under the upper edge, as much as possible, so that the escaping air passed through and loosened up the material on that side; wedged up and strained the pipe as before, and with a battering-ram, made of a twelve inch squre oak timber, twelve feet long, and in the middle suspended from shear-poles, struck successive blows against the top of the pile while it was descending, it was thus quickly brought into position.

A pneumatic pile is easier kept vertical than straightened afterward. In most cases it may be guided in its descent by a platform attached to wooden piles driven around it.

Gen. Smith presented a plan for sinking any depth pneumatic piles and caissons, through sand, whereby the excavation is made without exposing workmen generally to the injurious effects of compressed air, which increase with the depth, and, below sixty feet, are dangerous.

For a pneumatic pile, there should be a short section at the bottom, covered with a plate, through which there are a man-hole and valve, a supply, and one or more discharge pipes—the latter made telescopic, and with joints, so that a workman, standing on the plate, may cause the mouth of the pipe to traverse the surface to be excavated beneath the pile. Thus air, forced into the closed section through the supply pipe, would escape through the discharge pipe, and carry with it the material to be removed.

In a caisson, the same principle may be carried out. Men need enter the compressed air chamber only to remove an unusual obstruction.

Such a method is required in sinking foundations to very great depths. The greater the depth, the more efficient is the *air-lift* described.

Of course, this plan cannot be adopted where the material to be removed will not yield and flow with an air current.

A paper by Robert Cartwright, C. E., of Cleveland, Ohio, on "The Manufacture of Pneumatic Piles," was read.

The bridging of the Missouri river was a necessity to the railroads connecting the east and west of this country. The river is a rapid running, turbid stream, with a bed of treacherous, shifting material, and a channel which changes at every flood.

The bridge at Omaha has eleven spans, 250 feet long; and at Leavenworth, three spans, 340 feet long; both Post's truss, upon pneumatic pile piers. The manufacture of cylinders for these is here described:

First, there was built a brick pit, forty-seven feet internal diameter and fourteen feet deep, water-tight; with a foundation in the centre for a twenty-five ton crane, and four buttresses therefrom, dividing the pit into quarters, each to take two moulds.

For access to the moulds, and to supply air during casting, and subsequent cooling, there was a tunnel from each quarter to a shaft sunk outside of the pit. Each mould was built of fire-brick, laid in loam, upon a level cast-iron bed plate, and covered with another similar plate—the two being firmly bolted together. Outside the mould was a casing of sheet-iron—a space of a foot between the two being filled with spalls, cinder, and moulding-sand, which allowed the passage of escaping gases. The remaining spaces in the pit were also filled with sand. From the centres of each bed plate up to the top of the mould was a vertical wrought iron shaft, upon which the core barrel centred. The inside of the mould was coated about five-eighths inch thick with loam, brought to a true surface with a "strike" board revolving about the shaft. That the castings might be of uniform section under the difference of ferro-static head, the diameter of the mould at the bottom was made three-sixteenths inch less than at the top. The core-barrel consisted of six or more staves, or circular segments, strengthened by ribs cast on them, and bolted to two circular spiders, which were attached to a central hollow shaft, bored to receive the shaft fixed in the bed-plate of the mould—the whole being so arranged that the hollow shaft and spiders could be withdrawn together, and the staves left in position, to be afterwards removed singly. The barrel was coated with loam, to which a small quantity of chopped hay had been added—no rope being used.

When the mould was coated and dried, and the core in place, it

was covered with a plate or trough, coated with loam, and well fastened down; through this were twelve holes, one and a half inch in diameter for pouring "sprues," and six elliptical holes about three and a half by one and a half inches for "risers;" the last were about twelve inches high and six inches diameter at top, and were an effectual substitute for a "sinking head." A casing was then placed about the covering plate, forming a "runner" around the whole top of the mould, connected with a pouring basin, which had two outlets, each stopped by a "straining" gate, to retain the slag.

The mould was filled to the top of the risers, the iron entering simultaneously at twelve equi-distant points, and as shrinkage took place, fresh metal was supplied, and churned with coated rods. When the iron was "set," the runner casing was taken away, the "sprues" and "risers" broken off with a sledge; and, in rapid succession, the covering plate and the several parts of the core barrel removed, leaving the red hot section just cast, in the mould, and free to shrink uniformly as it rapidly cooled, without danger to its shape or sound ness. In about fourteen hours after pouring, the section (weighing nine tons), was taken from the mould, which was then freshly coated with loam. The bricks were usually hot enough to nearly dry it. As its parts were withdrawn, the core barrel was put together, and then coated with loam, which was almost dried by the heat retained. The barrel was then placed vertically on a car, and run into the core oven, which was large enough to receive four.

The loam was prepared in a loam-mill, consisting of a revolving pan and two heavy cast-iron chasers. It was, with the addition of a little fresh material, repeatedly used.

With eight moulds and six core barrels, one, and sometimes two sections were made daily for months. Two hundred and eighty-one sections were cast, eight and a half feet in diameter, ten feet long—some one and three quarter inch and the others one and a half inch thick—each with a four and a half inch inside flange, two and a half inches thick at each end. Of these, only one was lost, and this by the breaking of a brace after the mould was nearly full. The two flanges were faced in a lathe at the same time, and then each drilled with sixty-one holes for one and an eighth inch bolts.

A paper by C. D. Ward, C. E., of Jersey City, N. J., giving "Description of Screw Piles for supporting a twenty-four inch Water Main across the Providence River, Providence, R. I.," was read.

The piles were placed in a single row, twelve feet apart, with a cap or rest, on the top of each, in which the water pipe rests.

They were each twenty-two feet long, ten inches exterior diameter, one inch thick, and weighed about 2500 lbs. The largest diameter of screws was three feet, and the pitch was ten inches; there were two threads, each making about three-fourths of a turn.

The piles descended from six to eight and a half inches per revolution, and were put down by eight to twenty-one men, with ropes attached to levers, ten and a half feet long. The direction of draft reduced the effective leverage to about seven and a half feet.

Twelve piles were put down from nine to twelve feet each, in sand and gravel, in five days. When regularly moving, the ordinary rate of sinking was about two feet per minute.

New Explosives.—MM. Houzeau and Renard have lately been quite successful in applying ozone as a reagent in chemical research. In a paper recently made public, in which these gentlemen detail the results of some recent discoveries, they object to the method of oxidation generally pursued in organic chemistry (namely, the employment of substances rich in oxygen, such as chromic or nitric acids, sulphuric acid and bichromate of potassa, &c.), inasmuch as the action is complicated by the constituents of the mixtures employed, and their employment is often positively detrimental, on account of the somewhat elevated temperature which at times must be employed. For these and several other reasons, the authors in question strongly recommend the employment of ozone, since it is an energetic oxidizer, and can be employed at a low temperature, and introduces the least possible amount of complexity in the investigation.

As a direct result of these suggestions, they announce that when pure benzin, boiling at 81° C., is treated with concentrated ozone, it is transformed partly into several acid products (formic and acetic acids), while at the same time there is deposited a gelatinous precipitate, to which they attach the name of ozobenzine. Dried in vacuo, it presents the appearance of a white amorphous solid. It is an eminently explosive substance. It detonates with violence when struck, or when simply heated, and for this reason is extremely dangerous to handle.

Ozobenzin is very unstable in the air. Water decomposes and dissolves it.

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THE BOYDEN PREMIUM.

URIAH A. BOYDEN, ESQ., of Boston, Mass., has deposited with the Franklin Institute the sum of one thousand dollars, to be awarded as a premium to

"Any resident of North America who shall determine by experiment whether all rays of light, and other physical rays, are or are not transmitted with the same velocity."

The following conditions have been established for the award of the premium:

1. Any resident of North America, or of the West India Islands, may be a competitor for the premium; the southern boundary of Mexico being considered as the southern limit of North America.

2. Each competitor must transmit to the Secretary of the Franklin Institute a memoir, describing in detail the apparatus, the mode of experimenting, and the results; and all memoirs received by him before the first day of January one thousand eight hundred and seventy-three, will, as soon as possible after this date, be transmitted to the Committee of Judges.

3. The Board of Managers of the Franklin Institute shall, before the first day of January, one thousand eight hundred and seventy three, select three citizens of the United States, of competent scientific ability, to whom the memoir shall be referred; and the said Judges shall examine the memoirs and report to the Franklin Institute whether, in their opinion, and, if so, which of their memoirs is worthy of the premium. And, on their report, the Franklin Institute shall decide whether the premium shall be awarded as recommended by the Judges.

4. Every memoir shall be anonymous, but shall contain some motto or sign by which it can be recognized and designated, and shall be accompanied by a sealed envelope, endorsed on the outside with same motto or sign, and containing the name and address of the author of the memoir. It shall be the duty of the Secretary of the Franklin Institute to keep these envelopes securely and unopened until the Judges shall have finished their examination; when, should the Judges be of opinion that any one of the memoirs is worthy of the premium, the corresponding envelope shall be opened, and the name of the author communicated to the Institute.

5. Should the Judges think proper, they may require the experiments described in any of the memoirs to be repeated in their presence.

6. The memoirs presented for the premium shall become the property of the Franklin Institute, and shall be published as it may direct.

Contents for June, 1873.

Illustrations—Two Plates and Twelve Woodcuts.

EDITORIAL.